Mark Scheme (Results)

June 2019

Pearson Edexcel International Advanced Level
In Physics (WPH04)
Paper 01 Physics on the Move

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

June 2019
Publications Code WPH04_01_MS_1906

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 2018
Publications Code WPH04_01_MS_1801*

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.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities. Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

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. 'resonance'

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	Answer	Mark
1	The only correct answer is **C** A is not the correct answer because proton number has decreased and mass number has increased B is not the correct answer because proton number has decreased D is not the correct answer because mass number has increased	**1**
2	The only correct answer is **C** A is not the correct answer because it is 570 ÷ (60 × 2π) B is not the correct answer because it is 570 ÷ 60 D is not the correct answer because it is 570 × 2π)	**1**
3	The only correct answer is **A** B is not the correct answer because it says the force is downwards C is not the correct answer because the force is has been multiplied by 2 D is not the correct answer because the force is has been multiplied by 2 and it says the force is downwards	**1**
4	The only correct answer is **B** A is not the correct answer because it does not violate conservation of charge or lepton number C is not the correct answer because it does not violate conservation of charge or lepton number D is not the correct answer because it does not violate conservation of charge or lepton number	**1**
5	The only correct answer is **C** A is not the correct answer because it does not account for the increase in distance B is not the correct answer because the distance has not been squared in the new determination D is not the correct answer because the charge has not been squared in the new determination	**1**
6	The only correct answer is **D** A is not the correct answer because frequency remains constant B is not the correct answer because the particles are gaining energy C is not the correct answer because the rest mass of the particles is not increasing	**1**
7	The only correct answer is **D** A is not the correct answer because this is simply the mean of the magnitudes B is not the correct answer because this is the sum of the magnitudes C is not the correct answer because this is the sum of the squares of the magnitudes without taking the square root	**1**
8	The only correct answer is **B** A is not the correct answer because the trigonometrical ratio used is adjacent/opposite C is not the correct answer because a negative northward component has been applied and the trigonometrical ratio used is adjacent/opposite D is not the correct answer because a negative northward component has been applied	**1**
9	The only correct answer is **C** A is not the correct answer because this would increase the diameter B is not the correct answer because this would increase the diameter D is not the correct answer because this would increase the diameter	**1**
10	The only correct answer is **C** A is not the correct answer because there is division by a factor of 2	**1**

	B is not the correct answer because 2 × mass is in the denominator D is not the correct answer because the factor of 2 has not been included in the square root	

Question Number	Answer		Mark
11	Use of $E = kQ / r^2$ E =25 000 N C^{-1} (accept V m^{-1}) (Radially) outward from centre of sphere (accept outward, away from sphere, away from centre, do not accept away from charge) Example of calculation $E = 8.99 \times 10^9$ N m^2 C^{-2} $\times 34 \times 10^{-9}$ C ÷ (0.11 m)^2 = 25 300 N C^{-1}	**(1)** **(1)** **(1)**	**3**
	Total for question 11		**3**

Question Number	Answer	Mark
***12**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Max 6 • Atoms (in the sculpture) have protons and neutrons in nucleus • (Nucleus) is orbited by electrons • The electron is (the only) lepton • Nucleus is much smaller than the size of the atom, so mostly empty space • Proton **and** neutron are baryons • Baryons made of 3 quarks **Or** proton **and** neutron made of 3 quarks • Protons and neutrons are made of 1^{st} generation quarks (accept proton made of uud quarks **and** neutron made of ddu quarks for points 6 and 7)) • There are no antiquarks	**6**
	Total for question 12	**6**

Question Number	Answer		Mark
13(a)	Multiply by 1.60×10^{-19} C Divide by $(3.00 \times 10^{8}\ \text{m s}^{-1})^{2}$ $m = 2.24 \times 10^{-28}$ (kg) <u>Example of calculation</u> $m = 126 \times 10^{6} \times 1.60 \times 10^{-19}\ \text{C} \div (3.00 \times 10^{8}\ \text{m s}^{-1})^{2}$ $= 2.24 \times 10^{-28}$ kg	**(1)** **(1)** **(1)**	**3**
13(b)	Use of $\Delta E = c^{2}\Delta m$ (ecf for m from (a)) **Or** $\Delta E = 126 \times 10^{6} \times 1.60 \times 10^{-19}$ C Use of $E = hf$ $f = 1.52 \times 10^{22}$ Hz <u>Example of calculation</u> For one photon, $\Delta E = 2.24 \times 10^{-28}\ \text{kg} \times (3.00 \times 10^{8}\ \text{m s}^{-1})^{2} / 2$ $= 1.01 \times 10^{-11}$ J $f = 1.01 \times 10^{-11}\ \text{J} / 6.63 \times 10^{-34}$ J s	**(1)** **(1)** **(1)**	**3**
13 (c)	States initial charge = 0 and applies conservation of charge to show statement is incorrect (accept initial lepton number = 0 and applies conservation of lepton number to show statement is incorrect) Particle path shows (two) different directions of curvature Must really be 2 electrons and 2 positrons/antielectrons (accept 2 negative and 2 positive particles)	**(1)** **(1)** **(1)**	**3**
	Total for question 13		**9**

Question Number	Answer		Mark
14(a)(i)	$m_A > m_B$ – both move off to the right (accept 'forwards' for 'to the right')	**(1)**	**1**
14(a)(ii)	$m_A = m_B$ - trolley A stops and trolley B moves off to the right (accept 'forwards' for 'to the right')	**(1)**	**1**
14(a)(iii)	$m_A < m_B$ – trolley A moves off to the left and trolley B moves off to the right (accept 'forwards' for 'to the right' and 'backwards' for 'to the left')	**(1)**	**1**
14(b)(i)	Use of $p = mv$ $v = (-)\ 0.28$ (m s^{-1}) from graph Apply conservation of momentum $v = 0.31$ m s^{-1} <u>Example of calculation</u> Initial momentum of A = 0.5 kg × 0.6 m s^{-1} = 0.3 N s 0.3 N s = 1.4 kg × v_B – 0.5 kg × 0.28 m s^{-1} $v_B = 0.31$ m s^{-1}	**(1)** **(1)** **(1)** **(1)**	**4**
14 (b)(ii)	Use of $E_K = ½\ mv^2$ (ecf from i) Correct evaluation of a kinetic energy value Conclusion using correct results, e.g. kinetic energy conserved, so elastic <u>Example of calculation</u> E_K = ½ × 0.5 kg × (0.6 m s^{-1})^2 = 0.090 J before collision E_K = ½ × 0.5 kg × (0.28 m s^{-1})^2 + ½ × 1.4 kg × (0.31 m s^{-1})^2 = 0.087 J after collision	**(1)** **(1)** **(1)**	**3**
	Total for question 14		**10**

Question Number	Answer	Mark
15(a)(i)	(Thermionic) emission of electrons from heated filament **Or** Thermionic emission of electrons from (heated) filament **(1)** Electrons accelerated by field (between anode and filament) **Or** the electrons gain kinetic energy due to work done by the field **(1)**	**2**
15(a)(ii)	Use of $qV = ½\, mv^2$ **(1)** $v = 6.9 \times 10^6$ m s^{-1} **(1)** <u>Example of calculation</u> 1.60×10^{-19} C × 135 V = ½ × 9.11×10^{-31} kg × v^2 $v = 6.89 \times 10^6$ m s^{-1}	**2**
15(b)(i)	Equates $F = mv^2/r$ and $F = BQv$ **(1)** Algebra including use of $p = mv$ for conclusion **(1)** <u>Example of derivation</u> $F = mv^2/r$ and $F = BQv$ $mv^2/r = BQv$ $mv/r = BQ$ $r = mv/BQ$ $p = mv$ so $r = p/BQ$	**2**
15 (b)(ii)	Use of $r=p/BQ$ **(1)** $B = 1.1 \times 10^{-3}$ T (Allow ecf of v from (a)(ii)) **(1)** <u>Example of calculation</u> 0.073 m / 2 = 9.11×10^{-31} kg × 6.89×10^6 m s^{-1} / B × 1.60×10^{-19} C $B = 1.1 \times 10^{-3}$ T	**2**
15(c)	**Max 2** Camera allows magnification **or** camera avoids unsteadiness of hand But as the scale isn't against the object being measured there will be parallax errors **or** as camera cannot 'line up' with both sides at the same time there will be parallax errors difficult to align ruler with maximum distance between sides of circle **or** thickness of path makes it difficult to measure diameter resolution of metre rule is small relative to the measurement **Or** percentage uncertainty in measured value is low	**2**
15(d)	Electron collisions decreases E_K / speed / momentum of electrons, reducing radius/diameter **Or** (accelerating) electrons emit (synchrotron) radiation, reducing the E_K / speed / momentum of the electrons, reducing radius/diameter **(1)** Electrons scattered/absorbed by helium so intensity of beam decreases **Or** There are fewer electrons in the beam so the intensity decreases **(1)**	**2**
	Total for question 14	**12**

Question Number	Answer		Mark
16 (a) (i)	Equally spaced parallel lines perpendicular to and touching the plates (at least 3 lines) Arrows from X to Y	**(1)** **(1)**	**2**
16(a) (ii)	It is a uniform field **Or** field strength is constant $F = EQ$ so magnitude of force is constant	 **(1)** **(1)**	**2**
16 (b)(i)	Use of $E = V/d$ with 5000 V and 0.095 m Use of $F = EQ$ Use of $F = ma$ $a = 0.21$ (m s^{-2}) <u>Example of calculation</u> $E = 5000\ \text{V} / 0.095\ \text{m} = 52\ 600\ \text{V m}^{-1}$ $F = 11 \times 10^{-9}\ \text{C} \times 52\ 600\ \text{V m}^{-1} = 5.79 \times 10^{-4}\ \text{N}$ $a = 5.79 \times 10^{-4}\ \text{N} / 0.0027\ \text{kg} = 0.214\ \text{m s}^{-2}$	**(1)** **(1)** **(1)** **(1)**	**4**
16 (b) (ii)	Use of $v^2 = u^2 + 2as$ (ecf for a from (b)(i)) (accept other combinations of equations of motion leading to v) Use of $p = mv$ $p = 4.1 \times 10^{-4}$ N s **Or** $p = 4.1 \times 10^{-4}$ kg m s^{-1} **OR** Use of $s = ut + ½ at^2$ (ecf for a from (b)(i)) (accept other combinations of equations of motion leading to t) Use of $\Delta p = F\Delta t$ $p = 4.1 \times 10^{-4}$ N s **Or** $p = 4.1 \times 10^{-4}$ kg m s^{-1} <u>Example of calculation</u> $v^2 = u^2 + 2as$ $v^2 = 0 + 2 \times 0.21\ \text{m s}^{-2} \times 0.055\ \text{m}$ $v = 0.15\ \text{m s}^{-1}$ $p = 0.0027\ \text{kg} \times 0.15\ \text{m s}^{-1} = 4.1 \times 10^{-4}\ \text{N s}$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
16(b) (iii)	Use of $F = \Delta p / \Delta t$ With $\Delta p = 2 \times p$ from part (ii) (ecf from part (ii)) $F = 0.86$ N <u>Example of calculation</u> $F = 2 \times 4.1 \times 10^{-4}\ \text{N s} / 9.5 \times 10^{-4}\ \text{N s}$ $F = 0.86$ N	**(1)** **(1)** **(1)**	**3**
	Total for question 16		**14**

Question Number	Answer		Mark
17(a)	Calculate ln (V/V_0) / $-t$ for different corresponding values of V and t using data from graph	**(1)**	
	The calculated results should be equal (for a capacitor)	**(1)**	
	Or		
	Measure from the graph the time for V to decrease to/by a given fraction more than once	**(1)**	
	The times should be equal (for a capacitor)	**(1)**	
	Or		
	Use values from the graph to plot ln(V) against t	**(1)**	
	It should be a straight line with negative gradient (for a capacitor)	**(1)**	
	Or		
	Measure from the graph values of V at equal time intervals	**(1)**	
	The ratio of successive values of V should be equal (for a capacitor)	**(1)**	**2**

17 (b)(i)	Use of V_0 / e **or** Use of $0.37 \times V_0$ (accept use of any stated V value) Read time constant value off graph = 0.17 (s) (range 0.16 – 0.18 s) Use of time constant = RC C = 14 (nF) (range 13 nF to 15 nF) **Or** Draws tangent to line at t = 0 s Read time constant value off graph = 0.17 (s) (range 0.16 – 0.18 s) Use of time constant = RC C = 14 (nF) (range 13 nF to 15 nF) **Or** record a pair of values of V and t from graph use of $V = V_o\, e^{-t/RC}$ convert to correct logarithmic form C = 14 (nF) (range 13 nF to 15 nF) $V_0 / 2 = V_o\, e^{-t_{½}/RC}$ $RC = t_{½} / \ln 2$ Records time for V to fall to ½ (0.12 s) (range 0.11 – 0.12 s) C = 14 (nF) (range 13 nF to 15 nF) <u>Example of calculation</u> 1500 V / e = 552 V time constant value off graph = 0.17 (s) 0.17 s / 12 000 000 Ω = 14 nF	**(1)** **(1)** **(1)** **(1)**	**4**
17 (b)(ii)	Use of $Q = CV$ (ecf for C from (i)) $Q = 2.1 \times 10^{-5}$ (C) **Or** for 45 μC, V = 3200 V <u>Example of calculation</u> $14\text{ nC} \times 1500\text{ V} = 2.1 \times 10^{-5}\text{ C}$	**(1)** **(1)**	**2**
17(b)(iii)	Use of $W = ½\, QV$ **or** $W = ½\, CV^2$ **or** $W = ½\, Q^2/C$ (ecf for C from (i)) W = 0.016 J <u>Example of calculation:</u> $W = ½ \times 2.1 \times 10^{-5}\text{ C} \times 1500\text{ V} = 0.016\text{ J}$	**(1)** **(1)**	**2**
17(c)	Allows simultaneous readings of p.d. and time to be taken Allows a large number of readings to be taken (in a short space of time)	**(1)** **(1)**	**2**
***17(d)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) (Varying) current produces varying magnetic field Changing flux linkage with second coil **Or** lines of magnetic flux cut the wires in the second coil <u>E.m.f.</u> <u>induced</u> Complete circuit, so current in capacitor charging circuit	 **(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 17		**16**