Mark Scheme (Results)

Summer 2016

Pearson Edexcel GCE
in Physics (6PH04) Paper 01
Physics on the Move

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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.

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.

For example:

(iii) Horizontal force of hinge on table top

66.3 (N) or 66 (N) **and** correct indication of direction [no ue] ✓ **1**
[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.]

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 $g = 10\ \text{m s}^{-2}$ or $10\ \text{N kg}^{-1}$ instead of $9.81\ \text{m s}^{-2}$ or $9.81\ \text{N kg}^{-1}$ will be penalised by one mark (but not more than once per clip). Accept $9.8\ \text{m s}^{-2}$ or $9.8\ \text{N kg}^{-1}$

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:

$80 \text{ cm} \times 50 \text{ cm} \times 1.8 \text{ cm} = 7200 \text{ cm}^3$

$7200 \text{ cm}^3 \times 0.70 \text{ g cm}^{-3} = 5040 \text{ g}$

$5040 \times 10^{-3} \text{ kg} \times 9.81 \text{ N/kg}$

$= 49.4 \text{ N}$

5. Quality of Written Communication

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

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

6. Graphs

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

6.2 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.

6.3 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.

6.4 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.

6.5 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	D	**1**
2	B	**1**
3	B	**1**
4	A	**1**
5	B	**1**
6	A	**1**
7	B	**1**
8	C	**1**
9	D	**1**
10	B	**1**

Question Number	Answer	Mark
11(a)	Use of $E_k = eV$ **and** $E_k = p^2/2m$ **(1)** Use of $\lambda = \frac{h}{p}$ **(1)** $\lambda = 2.2 \times 10^{-11}$ (m) **(1)** **Or** Use of $E_k = eV$ **and** $E_k = \frac{1}{2}mv^2$ **(1)** Use of $\lambda = \frac{h}{p}$ **(1)** $\lambda = 2.2 \times 10^{-11}$ (m) **(1)** <u>Example of calculation</u> $v = \sqrt{\frac{2 \times 3000\ \text{V} \times 1.6 \times 10^{-19}\ \text{C}}{9.11 \times 10^{-31}\ \text{kg}}} = 3.2 \times 10^{7}\ \text{m s}^{-1}$ $\lambda = \frac{6.63 \times 10^{-34}\ \text{J s}}{9.11 \times 10^{-31}\text{kg} \times 3.2 \times 10^{7}\text{m s}^{-1}} = 2.24 \times 10^{-11}\ \text{m}$	**3**
11(b)	Compares λ to atomic gap spacing **and** makes comment consistent with their answer to (a) **(1)**	**1**
	Total for question 11	**4**

Question Number	Answer	Mark
12(a)	Photon causes no ionisation **(1)**	**1**
12(b)	The ejected electron has higher speed/momentum **(1)** Refers to $r = mv/BQ$ so r is bigger **(1)**	**2**
12(c)	Charge before collision = 0 **Or** identifies that both photon and hydrogen are neutral **(1)** Identifies that after collision hydrogen charge = +1 **and** electron charge = -1 (×2) **and** positron charge = +1 **(1)** (do not accept an electron position pair is neutral)	**2**
12(d)	**Either** The velocity/E_k of the ionised hydrogen atom is very small (accept negligible or zero) after collision **Or** it is stationary **(1)** (Compared to other particles in the interaction) the hydrogen atom has a large mass **(1)** **Or** The interaction is with the atomic electron not the nucleus **(1)** so the nucleus doesn't move **(1)**	**2**
	Total for question 12	**7**

Question Number	Answer	Mark
13(a)	Increasing d will lead to a decrease in *C* **Or** see $Q/V = k/d$ **(1)** Since $C = Q/V$ (a decrease in *C*) means a decrease in the charge on the capacitor **Or** if *V* is constant (a decrease in *C*) means a decrease in charge on capacitor **(1)**	**2**
13(b)	Use of $C = k/d$ with $d = 4.2$ (mm) **(1)** use of $Q = CV$ *with* $V = 6$ V or cancelled later **(1)** use of $\Delta Q/Q$ or $\Delta C/C$ **(1)** % change = 17% **(1)** Example of calculation $Q = \frac{6\text{ V} \times 2.8\times10^{-15}\text{ F m}}{3.5\times10^{-3}\text{ m}} = 4.8\times10^{-12}$ C $Q = \frac{6\text{ V} \times 2.8\times10^{-15}\text{ F m}}{4.2\times10^{-3}\text{ m}} = 4.0\times10^{-12}$ C $\frac{4.8\times10^{-12}\text{ C} - 4.0\times10^{-12}\text{ C}}{4.8\times10^{-12}\text{ C}} = 16.7\%$	**4**
13(c)	(rapid changes in position) mean that rapid changes in Q **Or** a shorter time to charge/discharge **(1)** (small C gives) shorter time constant/RC **(1)**	**2**
	Total for question 13	**8**

Question Number	Answer	Mark
*14(a)(i)	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** Measure the mass of each glider **(1)** Measure the length of the card **(1)** Recognise the time (for the card) to pass the light gate **(1)** Calculate the velocity using length (of card)/time **(1)** Recognise the need to show that $m_1v_1 = (m_1+m_2)v$ **Or** the equivalent description in words **(1)**	**5**
14(a)(ii)	Law of conservation of momentum only applies when no external forces act **(1)** Friction would be an external force **Or** Friction would alter/affect the velocities (immediately before and after the collision) **Or** there is time between the readings during which friction acts **(1)**	**2**
14(b)(i)	Use of $p=mv$ to determine momentum before **and** after collision **(1)** v = 0.50 m s^{-1} **(1)** <u>Example of calculation</u> $v = \frac{(0.50\text{ kg} \times 0.90\text{ m s}^{-1})-(0.50\text{ kg} \times 0.20\text{ m s}^{-1})}{0.70\text{ kg}} = 0.50\text{ m s}^{-1}$	**2**
14(b)(ii)	E_k before collision = 0.20 J **(1)** E_k after collision = 0.10 J hence inelastic collision (ecf from (b)(i) **(1)** (correct calculation of energy difference = 0.1 J and conclusion scores both marks) <u>Example of calculation</u> Before $E_k = \frac{1}{2} \times 0.50\text{ kg} \times (0.90\text{ m s}^{-1})^2 = 0.20\text{ (J)}$ After $E_k = \left(\frac{1}{2} \times 0.50\text{ kg} \times (0.20\text{ m s}^{-1})^2\right) + \left(\frac{1}{2} \times 0.70\text{ kg} \times (0.50\text{ m s}^{-1})^2\right) = 0.098\text{ (J)}$	**2**
	Total for question 14	**11**

15(a)(i)	(Magnetic) flux linkage **(1)** Weber /Wb (accept T m^2) **(1)**	**2**
15(a)(ii)	The (induced) <u>e.m.f</u> is such as to <u>oppose the change</u> creating it **(1)**	**1**
***15(b)(i)**	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** There is a changing flux (linkage) **Or** magnetic field lines are cut by the coil **(1)** Inducing an e.m.f .(across the coil) **(1)** There is a current since there is a closed circuit **(1)**	**3**
15(b)(ii)	The rate of change of flux changes **(1)** as speed changes **Or** because flux density at coil changes with distance (MP2 dependent on MP1) **(1)**	**2**
15(b)(iii)	More readings in a short time **Or** increased sampling rate **(1)**	**1**
	Total for question 15	**9**

Question Number	Answer	Mark
16(a)(i)	Use of $v = \frac{2\pi r}{T}$ **Or** $v = rw$ **(1)** v = 2.1 m s^{-1} **(1)** <u>Example of calculation</u> $v = \frac{2\pi \times 0.4\ \text{m}}{1.2\ \text{s}}$ = 2.09 m s^{-1}	**2**
16(a)(ii)	Radius/circumference decreased **(1)** Measured speed greater than actual speed (dependent on first mark) **(1)**	**2**
16(a)(iii)	Use of $F = Bqv$ **(1)** $F = 5.9 \times 10^{-24}$ N **(1)** <u>Example of calculation</u> $F = 0.05\ \text{T} \times 1.6 \times 10^{-19}\text{C} \times 7.4 \times 10^{-4}\ \text{m s}^{-1} = 5.9 \times 10^{-24}$ N	**2**
16(b)	Use of $R\cos\theta = mg$ **and** $R\sin\theta = F$ **Or** $\tan\theta = F/mg$ **(1)** Use of $F = \frac{mv^2}{r}$ (do not award if mg used as the force) **(1)** r = 20 m **(1)** (g =10 m s^{-2} leads to r = 20.04 m scores MP1 & 2 only) <u>Example of calculation</u> $r = \frac{mv^2}{mg\tan\theta} = \frac{v^2}{g\tan\theta}$ $r = \frac{(9\ \text{m s}^{-1})^2}{9.81\ \text{m s}^{-2} \times \tan 22°} = 20.4\ \text{m}$	**3**
	Total for question 16	**9**

Question Number	Answer	Mark
17(a)	Vertical and equally spaced parallel lines (minimum 3, ignore any at edges which are curved) **(1)** Arrows downwards **(1)**	**2**
17(b)	Identifies an upward electric force **(1)** Which is equal to the weight **Or** which balances the weight **Or** the resultant force on the drop is zero **(1)**	**2**
17(c)	See $F=VQ/d$ **(1)** Equates electric force and weight **(1)** $Q/m = 49 \times 10^{-6}$ (C kg^{-1}) **(1)** <u>Example of calculation</u> $F = EQ = \frac{VQ}{d} = mg$ $\frac{Q}{m} = \frac{gd}{V}$ $\frac{Q}{m} = \frac{9.81\text{m s}^{-2} \times 2.5{\times}10^{-2}\text{ m}}{5000\text{ V}} = 4.9 \times 10^{-5}$ (C kg^{-1})	**3**
17(d)	Uses $\frac{Q}{m}$ to find Q (ecf value from (c)) ($Q = 4.9 \times 10^{-18}$ C) **(1)** Use of $F = \frac{kQ_1Q_2}{r^2}$ **(1)** $F = 4.5 \times 10^{-20}$ N **(1)** (using show that value from (c) gives 4.64×10^{-20} N) <u>Example of calculation</u> $F = \frac{8.99{\times}10^{9}\text{ N m}^2\text{C}^{-2}(4.9{\times}10^{-5}\text{ C kg}^{-1}{\times}\ 1.0{\times}10^{-13}\text{ kg})^2}{(2.2{\times}10^{-3}\text{ m})^2} = 4.46 \times 10^{-20}$ N	**3**
17(e)	As V increases the electric/upwards force increases **Or** EQ > mg **(1)** There is a resultant force **(1)** Drops (initially) accelerate upwards **(1)**	**3**
	Total for question 17	**13**

Question Number	Answer	Mark
18(a)	Divide by 1.6×10^{-19} **(1)** $V = 4.5 \times 10^6$ V **(1)** <u>Example of calculation</u> $V = \dfrac{7.2 \times 10^{-13}\text{ J}}{1.6 \times 10^{-19}\text{ C}} = 4.5 \times 10^6\text{ V}$	**2**
18(b)	Line of best fit drawn with maximum speed $<3 \times 10^8$ **(1)** Comment that line tends towards *c* **Or** comments that the graph levels off close to *c*. **(1)**	**2**
18(c)	The idea that as electrons travel at speeds close to the speed of light their mass increases **(1)** $E_k = \frac{1}{2}mv^2$ does not apply **Or** relativistic equations should be used. **(1)**	**2**
18(d)(i)	The time spent in each tube must remain constant (as the speed increases) **(1)** Refers to the tubes switching polarity at fixed time intervals **(1)** (For MP2 just saying frequency is constant is not sufficient)	**2**
18(d)(ii)	The speed of electrons has become a maximum/constant **Or** there can be no further increase in the speed of the electrons **(1)** (do not accept there is no acceleration)	**1**
	Total for question 18	**9**

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