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Mark Scheme (Results)

Summer 2012

GCE 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.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

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 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:

'Show that' calculation of weight

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. 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.

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

Question Number	Answer	Mark
11(a)	Repulsive force (due to two positive/like charges) **(1)** An explicit statement relating force/repulsion to acceleration (allow F = ma) **(1)** [candidates might start with the acceleration needing a force, this is acceptable]	2
11(b)	At least four straight evenly spaced radial lines starting from the circle. **(1)** Arrow pointing away from centre **(1)**	2
	Total for question 11	4

Question Number	Answer	Mark
12	Considers momentum **(1)** Calculates momentum of xenon or spacecraft **(1)** Calculates a second momentum **Or** calculates speed of spacecraft **(1)** A statement that the prediction is correct **Or** a statement that the increase is (about) $8ms^{-1}$ **(1)** (only award this mark if based on correct calculations) (Calculation to find the speed of the Xenon or either mass scores **max 3**) <u>Example of calculation</u> Momentum of Xenon = 0.13 kg × 30000 m s^{-1} = 3900 kg m s^{-1} Momentum of spacecraft = 486 kg × 8 m s^{-1} = 3888 kg m s^{-1} **Or** Momentum of Xenon = 0.13 kg × 30000 m s^{-1} = 3900 kg m s^{-1} Momentum of spacecraft = 486 kg × *v* *v*= 3900 kg m s^{-1} / 486 kg = 8.02 m s^{-1}	**4**
	Total for question 12	**4**

Question Number	Answer		Mark
13	[Some candidates calculate energy × 2 and divide by 2 later on. Others omit use of 2. Both methods are correct]		
	Uses only mass of 9.11×10^{-31} kg	**(1)**	
	Use of $E = mc^2$ for 1 or 2 particles	**(1)**	
	Use of $E = hf$	**(1)**	
	Use $c = f\lambda$	**(1)**	
	Wavelength = 2.43×10^{-12} m	**(1)**	**5**
	(Common wrong answers are 1.21×10^{-12} m and 0.60×10^{-12} m. These score 4 marks for correct method see below)		
	Some candidates are getting the correct value using only $\lambda = h/p$ using the mass of the positron and the speed of light to find a momentum. This method scores1 for mass of electron/positron Some candidates are using $E = mc^2$ and $\lambda = h/p$ They could score the first two marks.		
	Example of calculation $E = (9.11 \times 10^{-31}\text{ kg}) \times (9 \times 10^{16}\text{ m}^2\text{ s}^{-2}) = 8.2 \times 10^{-14}$ J $f = (8.2 \times 10^{-14}\text{ J}) / (6.63 \times 10^{-34}\text{ Js})$ $\lambda = (3 \times 10^{8}\text{ ms}^{-1}) / (1.2 \times 10^{20}\text{ s}^{-1})$ $\lambda = 2.43 \times 10^{-12}$ m		
	Total for question 13		**5**

Question Number	Answer	Mark
14	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Max5** **Electric fields** • can be used to accelerate/deflect particles **(1)** • direction of force/deflection indicates (sign of) charge. **(1)** • $a = EQ/m$ **(1)** **Magnetic fields** • produce circular motion **Or** provides a centripetal force **Or** causes spirals/arc **(1)** • Direction of force/curvature/deflection indicates (sign of) charge. **(1)** • momentum/speed/mass found from radius/curvature **(1)** • $r = p/BQ$ **Or** $Bqv = mv^2/r$ **(1)**	**5**
	Total for question 14	**5**

Question Number	Answer	Mark
15(a)(i)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate there is a magnetic field in stator/(iron) core **Or** the core becomes an electromagnet **(1)** This field/flux is changing (due to the AC input) **(1)** *B* field (from the stator) passes through the rotor **(1)** (the changing magnetic flux/field leads to an) induced emf/pd **(1)**	**4**
15(a(ii)	Rotor experiences a <u>force</u> **Or** mention of FLHR **Or** $F = BIl$ **(1)** Due to the current in the **rotor** being in a magnetic field **Or** rotor becomes a magnet **(1)**	**2**
15(a)(iii)	**Max 2** Increase frequency (of current) **(1)** Increase (magnitude of) current **(1)** Add more turns (to either coil) **(1)**	**2**
15(b)(i)	T = 60/33(1,82 s) **Or** f =33/60 (0.55 s^{-1}) **(1)** Use of $\omega = 2\pi/T$ **Or** $w = 2\pi/f$ **(1)** ω= 3.5 rad s^{-1} **(1)** [11.4 rad s^{-1} scores 1; 3.2 x 10^{-3} rad s^{-1} scores 1; 11 π/10 rad s^{-1} scores 2] <u>Example of calculation</u> $\omega = (33 \times 2\pi)/ 60$ s ω= 3.5 rad s^{-1}	**3**
15(b)(ii)	Use of $a = r\omega^2$ **(1)** a = 1.5 ms^{-2} [allow ecf from (b)(i)] **(1)** [11.4 rad s^{-1} gives 16 m s^{-2}] <u>Example of calculation</u> $a = (0.125 \text{ m}) \times (3.5 \text{ rad s}^{-1})^2$ a = 1.5 m s^{-2}	**2**
	Total for question 15	**13**

Question Number	Answer		Mark
16(a)(i)	Use of $t=RC$	**(1)**	
	Use of $T=1/f$ **Or** $f = 1/t$	**(1)**	
	Comparison of 2.2 x10^{-4} (s) << 2.5 x10^{-3} (s) **Or** comparison of 400 (Hz)<< 4500 (Hz) **Or** reference to nRC (needed for complete discharge) where n = 3 – 11 **Or** $e^{-T/t}$ is a very small value	**(1)**	**3**
16(a)(ii)	See $C = Q/V$ **Or** $Q = CV$	**(1)**	
	See $Q = It$	**(1)**	
	See $t = 1/f$ **Or** $f = 1/t$ (Answers based on t = RC and V = IR scores 0)	**(1)**	**3**
16(a)(iii)	sub in $C = I/fV$	**(1)**	
	C = 2.7 μF	**(1)**	**2**
	Example of calculation C = 5.4 × 10^{-3} A/ (400 s^{-1} × 5.0 V) C = 2.7 μF		
16(a)(iv)	2.2 + 30% = 2.9 (μF) **Or** shows that 2.7 (uF) is +22% of 2.2 (uF)	**(1)**	
	Within tolerance / consistent (2nd mark can only be awarded following an attempt at either of the above calculations)	**(1)**	**2**
	If candidates make an error in (iii) allow full ecf with a valid comment based on their values.		
16(b)	Use of ½ CV^2	**(1)**	
	W = 3.4 × 10^{-5} J (allow ecf from (iii) or use of 2.2 μF→2.75 × 10^{-5} J)	**(1)**	**2**
	Example of calculation W = ½ 2.7 μF × $(5.0\ V)^2$ W = 3.4 × 10^{-5} J		
	Total for question 16		**12**

Question Number	Answer		Mark
17(a)	Disc/metal/cathode is heated (by a current) Thermionic emission (allow use of extremely high pd **and** a vacuum for 2 marks)	**(1)** **(1)**	**2**
17(b)	See $F=mv_{(v)}/t$ **Or** $F=ma$ and $v_{(v)}=at$ See $F= eE$ (accept F = EQ) See (time in field is) $t= l/v$ (This needs to be three clear statements) (Do not credit a units method)	**(1)** **(1)** **(1)**	**3**
17(c)	Find/measure horizontal distance from plates to screen Find/measure vertical displacement from centre of screen Use tan θ (this mark can be awarded if velocities are used rather than distances)	**(1)** **(1)** **(1)**	**3**
17(d)	Tan θ = vertical velocity / horizontal velocity **Or** v_v/v $v_v = \frac{Ee}{m} \times \frac{l}{v}$ and $v_H = v$ (conditional mark) (Do not credit a units method) .	**(1)** **(1)**	**2**
17(e)(i)	Magnetic rather than electric <u>force</u> **Or** Bev/BQv is the magnetic force **Or** $F = Bev/BqV$ (do not credit just $eE = Bev$)	**(1)**	**1**
17(e)(ii)	Mark for appreciation of magnetic force e.g. Force/acceleration now centripetal **Or** (causes) circular motion **Or** force/acceleration not vertical **Or** force/acceleration is not always in the same direction **Or** vertical force/acceleration not constant **Or** force/acceleration is at right angles to direction of motion, Mark for consequence Horizontal velocity no longer constant **Or** l/v = t not true	**(1)** **(1)**	**2**
	Total for question 17		**13**

Question Number	Answer		Mark
18(a)	A sensible comment such as: A reference to symmetry Quarks in pairs (in the particle generations) 6 leptons known but only 5 quarks (do not credit for each quark there has to be an anti-quark)	**(1)**	**1**
18(b)(i)	Same mass Opposite charge	**(1)** **(1)**	**2**
18(b)(ii)	Conserve momentum Initial (total) momentum is zero (Ignore reference to other conservation laws)	**(1)** **(1)**	**2**
18(c)(i)	Recognise (G)eV units of energy (E = m c^2 so) E/c = mc = momentum (conditional mark) **Or** recognise (G)eV/c^2 is unit of mass Momentum is mass x velocity (conditional mark)	**(1)** **(1)** **(1)** **(1)**	**2**
18(c)(ii)	Vectors added in sequence after μ_2 Direction and magnitude of J3 and J4 accurate Judge by eye and do not penalise missing arrows	**(1)** **(1)**	**2**
18(c)(iii)	94 - 99 (GeV/c)	**(1)**	**1**
18(c)(iv)	7 values added together including the value from (iii) **Or** total length of vectors and × 10 (method mark)	**(1)**	**1**
18(c)(v)	Value in (iv) or 300 divided by 2	**(1)**	**1**
18(c)(vi)	**Max 2** Large mass **Or** top quark (very) heavy Large amount of energy required **Or** issue of providing sufficient energy Availability of antimatter is poor Difficulty of storing antimatter	**(1)** **(1)** **(1)** **(1)**	**2**
	Total for question 18		**14**

TOTAL MARKS FOR THIS PAPER = 80

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