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Mark Scheme (Results)

Summer 2012

GCE Physics (6PH02) Paper 01
Physics at Work

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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] [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.]	✓	**1**

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:

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

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

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

$= 49.4 \text{ N}$

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.

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

	Answer	Mark
11(a)	<table><tr><td>Switch combination</td><td>Total resistance of circuit</td></tr><tr><td>A open. B closed.</td><td>R</td></tr><tr><td>A open. B open.</td><td>$2R$</td></tr><tr><td>A closed. B closed.</td><td>$R/2$ or 0.5 R</td></tr><tr><td>A closed. B open.</td><td>$2R/3$ or 0.7 R</td></tr></table> **(1)** **(1)** **(1)** Answers must be in simplest form, e.g. not $R + R$	**3**
11(b)	Reference to $P = V^2/R$ **OR** $P= VI$ and $V=IR$ (Accept energy equations.) **(1)** (most power/energy) from the switch combination with the lowest resistance **(1)** [Ignore the table when awarding these method marks.]	**2**
11 (c)	(Internal resistance will) reduce current **Or** reduce V **Or** increase total R **Or** cause lost volts **Or** energy transferred to internal resistance **(1)** less energy/power output (in all combinations) **(1)**	**2**
	Total for question 11	**7**

Question Number	Answer	Mark
12(a)(i)	**Effect**: (Max) (K)E/speed/velocity (of electrons) increases (accept electrons move faster) **(1)** **Explanation**: (Increasing frequency) increases energy of <u>photon</u> **(1)** If there is reference to both energy and number of electrons increasing, do not award the first mark.	**2**
12(a)(ii)	**Effect**: Number (of electrons)/sec emitted increases / rate of (electron) emission increases (accept reference to increased current) **(1)** **Explanation**: There are more photons/sec **(1)** Either mark may be awarded without reference to '/sec' or rate, but only award 2 marks for the rate effect and explanation if there is reference to rate or '/sec' at least once If there is reference to both energy and number of electrons increasing, do not award the first mark.	**2**

12(b)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Observation from photoelectric effect (max 1 mark)** • No of electrons emitted depends on intensity / doesn't depend on frequency • Emission of electrons is instantaneous / no time delay • Minimum frequency for electron emission (i.e. reference to threshold frequency, not work function) • (Max) electron (kinetic) energy depends on frequency / doesn't depend on intensity (accept reference to stopping potential) **Explanation (max 3 marks):** **Particle nature** Reference to $E=hf$ or quanta of energy / packets of energy / photons **Use to explain observation** One photon releases one electron **Or** Electron release requires minimum energy / work function energy **Or** (Max) Electron energy is photon energy – work function energy **Or** $\frac{1}{2} mv^2 = hf - \varphi$ **Wave nature** Wave energy depends on intensity **Or** Energy spread over whole wave **Or** Energy supply is continuous (accept energy can build up) **Use to explain observation** So more intense light should give greater (K)E (which it doesn't) **Or** If given enough time electrons eventually released (which doesn't happen) **Or** a delay could be expected before electron release (which doesn't happen)	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 12		**8**

Question Number	Answer		Mark
13(a)	Conversion of kW to W Use of $P = V^2/R$ **OR** $P = VI$ **and** $V = IR$ R = 53 (Ω) (to at least 2 s.f.) [no ue] Example of calculation R = (230 V × 230 V) / 1000 A R = 52.9 Ω	**(1)** **(1)** **(1)**	**3**
13(b)	Use of $R = \rho l/A$ l = 6.3 m ('Show that' value gives 5.9 m) Example of calculation $l = RA/\rho$ l = 53 Ω × 1.3 × 10^{-7} m^2 /1.1 × 10^{-6} Ω m l = 6.3 m	**(1)** **(1)**	**2**
13(c)	If length halved, area must half (for same resistance) / state $A \propto l$ Use of area = πr^2 Diameter = 0.28 mm or 0.29 mm **OR** Use of the resistivity formula Use of area = πr^2 To give correct diameter for their values of length and resistance (0.14 mm scores 2 marks)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
	Total for question 13		**8**

Question Number	Answer		Mark
14(a)	(Atoms/electrons) gain energy (Electrons/atoms) move to higher energy levels/states **OR** level/state above ground state 'electron shells' not sufficient	**(1)** **(1)**	**2**
14(b)(i)	Electrons/atoms move to lower energy level/state (accept ground state) **Or** Electrons/atoms moves down from a higher energy level/state Emit photons **Or** emit quanta/packets of electromagnetic radiation (emit radiation not sufficient)	**(1)** **(1)**	**2**
14(b)(ii)	Atoms/electrons exist in certain/discrete/specific energy (levels) (do not allow 'fixed') Only certain energy changes are possible **Or** Only certain/discrete/ fixed amounts of energy are released (accept reference to 'amounts of eV' for energy) Refer to $E = hf$	**(1)** **(1)** **(1)**	**3**
14(b)(iii)	(Phosphor) has different energy level (spacing)s **Or** different elements have different energy level (spacing)s (Not shells, not different number, not configuration)	**(1)**	**1**
	Total for question 14		**8**

Question Number	Answer	Mark
15(a)	**Pulse-echo principle (Max 2 marks)** Pulse reflected at boundary/surface/foetus/where density changes **(1)** Time for (echo/reflected) pulse to return measured **(1)** Time (to return) depends on distance/depth **Or** distance calculated from time (to return) **(1)** (ignore any incorrect description of method) **Practical detail (Max 2 marks)** Many/large number of pulses/distances/times/results **(1)** Probe moved to different positions/angles **(1)** (Ultrasound) travels as pulses so that one pulse is detected before the next pulse is sent. **(1)**	**3**
15(b)	Involves a moving reflector/surface/boundary/heart/blood (not detector/not source) **(1)** Refers to a change in frequency/wavelength (Can be descriptive, e.g. causes wavefronts to be compressed when heart moving towards detector) **(1)** (Assume relative change in frequency or wavelength corresponds to movement unless explicitly incorrect)	**2**
15(c)	Use of speed = distance/time **(1)** Correct use of factor of 2 (thickness × 2 or calculated time × 2) **(1)** Time = 5.0×10^{-7} s **(1)** (Time = 2.5×10^{-7} scores 1 mark only for this method) (Method based on $v = f\lambda$ scores no marks.) <u>Example of calculation</u> Distance = thickness × 2 = 5×10^{-4} m × 2 Time = distance /speed t = 1×10^{-3} m /2000 m s^{-1} t = 5.0×10^{-7} s	**3**
	Total for question 15	**8**

Question Number	Answer	Mark
16(a)	Diffraction is the spreading out of a wave (not bending, not bending round, not just change in direction) **(1)** as it passes (through) a gap/slit/aperture **Or** passes (around) an obstacle **(1)** (No marks for diagram as it says 'state'.)	**2**
16(b)	Indication that two or more (waves) meet/overlap/coincide **(1)** The (total) <u>displacement</u> at a point is the sum of the individual <u>displacement</u>s **(1)**	**2**
16(c)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Identifies that the rock(s) or gap(s) in the rocks cause diffraction **Or** cause wave(front)s to become curved / waves to spread out **(1)** Waves/wavefronts (from each gap) overlap/meet **(1)** (At some places) waves are in phase (accept path difference equal to whole number of wavelengths) **Or** (at some places) waves are in antiphase (accept path difference equal to whole number of wavelengths plus half a wavelength) **(1)** Constructive superposition/interference occurs **Or** destructive superposition/interference occurs (must correspond to phase differences if referred to elsewhere) **(1)** Maximum/large <u>amplitude</u> erodes beach / disturbs sand the most **Or** minimum/zero <u>amplitude</u> doesn't disturb sand (as much) **Or** reduced <u>amplitude</u> disturbs sand less **(1)**	**5**
	Total for question 16	**9**

Question Number	Answer		Mark
17 (a)	Refraction	**(1)**	**1**
17(b)(i)	Normal correctly added to diagram *i* and *r* correctly labelled (consequent mark)	**(1)** **(1)**	**2**
17(b)(ii)	Greater refraction than the red light as light enters the raindrop (must be between red light ray and centre) Reflection followed by refraction away from normal as ray emerges from the raindrop.	**(1)** **(1)**	**2**
17(c)(i)	The angle of incidence (in the denser medium) for which angle of refraction is 90º **Or** angle of incidence for which a ray is transmitted along the boundary	**(1)**	**1**
17(c)(ii)	Use of sin *i* /sin *r* = μ with *i* = 90º **Or** sin *c* = 1/ μ c = 50º (N.B. missing º is a unit error) <u>Example of calculation</u> 1/sin c = 1.3 sin c = 1/1.3 c =50.3º	**(1)** **(1)**	**2**
17(d)	Substitution into $v = f\lambda$ $\lambda = 5.2 \times 10^{-7}$ m <u>Example of calculation</u> $\lambda = 2.2 \times 10^{8}$ m s^{-1} / 4.2×10^{14} Hz $\lambda = 5.2 \times 10^{-7}$ m	**(1)** **(1)**	**2**
	Total for question 17		**10**

Question Number	Answer		Mark
18(a)(i)	resultant e.m.f. = 15 V – 7.6 V = 7.4 V	**(1)**	**1**
18(a)(ii)	Total resistance = 0.65 Ω + 0.050 Ω = 0.70 Ω	**(1)**	**1**
18(a)(iii)	Use of $I = V/R$ I = 11 A (allow ecf for values from (i) & (ii)) (22.6 V gives 32.3 A) Example of calculation I = 7.4 V/ 0.7 Ω I = 10.6 A	**(1)** **(1)**	**2**
18(b)(i)	Use of p.d. across series resistance = 4.3 A× 0.65 Ω Subtraction of calculated p.d. value from 15 V Terminal p.d. = 12.2 (V) [no ue] **OR** Use of p.d. across internal resistance of battery = 4.3 A× 0.05 Ω Addition of calculated p.d. value to 12 V Terminal p.d. = 12.2 (V) [no ue] Example of calculation p.d. across internal resistance = 4.3 A× 0.65 Ω = 2.8 V Terminal p.d. = 15 V – 2.8 V Terminal p.d. = 12.2 V	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
18(b)(ii)	Use of $P = VI$ Rate of energy = 65 W Example of calculation Power = 15 V × 4.3 A Power = 64.5 W	**(1)** **(1)**	**2**
18(b)(iii)	Use of $P = I^2r$ (to find wasted power for internal resistance, series resistance or total resistance) (allow ecf from (a)(ii)) Subtraction of this value from answer to (b)(ii) (allow ecf) Efficiency = 80% (allow ecf) **Or** 12 V × 4.3 A (for useful power = 51.6 W) Use of ratio of useful power/total power Efficiency = 80% (efficiency = ratio of emfs leading to 80% scores 3 marks) Example of calculation Wasted power = $(4.3\ A)^2 \times 0.7\ \Omega$ = 13W Efficiency = (65 – 13)/65 Efficiency = 80%	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
	Total for question 18		**12**

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