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Mark Scheme (Results)

Summer 2013

GCE Physics (6PH02)

Paper 01R: 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.

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.

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

Question Number	Answer		Mark
11	current same in series **Or** current is different if not in series to ensure the total resistance in the circuit isn't increased **Or** to ensure no pd lost because that would reduce the current being measured [Just saying current changes or resistance changes is not sufficient for MP2 and 3. Candidates who **only** refer to what would happen if ammeter in parallel can only score MP1]	**(1)** **(1)** **(1)**	**3**
	Total for question 11		**3**

Question Number	Answer		Mark
12	Use of $V = IR$ Use of lost volts = emf − terminal pd **Or** use of total resistance − 6.6Ω (quoting $\varepsilon = I(R + r)$ or $\varepsilon = V + Ir$ gets both marks) Internal resistance = 0.54 Ω (rounding and different methods all give 0.5 Ω to 1 sig. fig .) Example of calculation V = 0.21 A × 6.6 Ω = 1.39 V Ir = 1.5 V – 1.39 V = 0.11 V r = 0.11 V ÷ 0.21 A = 0.54 Ω	**(1)** **(1)** **(1)**	**3**
	Total for question 12		**3**

Question Number	Answer		Mark
***13 (a)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) The waves superpose **Or** diffraction at the double slits	**(1)**	
	Where they are in phase **Or** when path difference is a whole number of wavelengths constructive interference takes place	**(1)**	
	Where they are in antiphase / when path difference is an odd number of half wavelengths destructive interference takes place	**(1)**	
	Bright bands are when waves are in phase / when path difference is $n\lambda$ / constructive interference **Or** reverse for dark bands	**(1)**	**4**
13 (b)	coherent = constant phase relationship/difference (between light arriving from the two sources) **Or** if they are not coherent the phase relationship/difference will vary.	**(1)**	
	The idea that at a given point there would sometimes be constructive interference and sometimes destructive interference etc	**(1)**	**2**
13 (c)	Interference (accept diffraction) only occurs with waves.	**(1)**	**1**
	Total for question 13		**7**

Question Number	Answer		Mark
14(a)	$Q = It$ stated A is a unit of current and h is a unit of time (hence Ah is charge) **Or** use of $Q = It$ with values in A and h Completed by conversion of h to s and use of C	**(1)** **(1)** **(1)** **(1)**	**2**
14(b)	Use of $W = IVt$ W = 10 000 J Example of calculation W = 0.19 A × 10 h × 1.5 V = 0.19 A × 10 × 60 × 60 s × 1.5 V W = 10260 J	**(1)** **(1)**	**2**
14(c)	Use of $W = QV$ Energy = 8600 J Example of calculation W = 7200 C × 1.2 V = 8640 J (lack of J only penalised once in (b) and (c))	**(1)** **(1)**	**2**
14(d)	Use of efficiency = (output energy/input energy) × 100% {It must be their (c) divided by their (b)} Efficiency = 86% (accept 0.86) Use of 10260 J →84% **ecf** their values from (b) and (c) (Do not award MP2 if efficiency is >100%) Example of calculation Efficiency = (8640 J ÷ 10000 J) × 100% = 86%	**(1)** **(1)**	**2**
	Total for question 14		**8**

Question Number	Answer		Mark
15 (a)	change in direction / wavelength (of wave/ray/light) (when entering a medium where) the wave has a different velocity **OR** (when entering a medium where) the density is different the light travels at a lower speed in the air than in a vacuum	**(1)** **(1)** **(1)**	**3**
15 (b)	identify angle of incidence = 64º use of sin *i* / sin *r* = refractive index *r* = 63.9° to at least 3 sf calculation of difference = 0.12º <u>Example of calculation</u> sin *r* = sin *i* ÷ *μ* = sin 64° ÷ 1.001 *r* = 63.88° difference = 0.12º	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 15		**7**

Question Number	Answer		Mark
16(a)	best fit line use of gradient **Or** use of R/l from graph or table use of $\rho = RA/l$ resistivity = 4.7×10^{-7} Ω m (range 4.5 to 4.8×10^{-7} Ω m) <u>Example of calculation</u> gradient = 4.4 Ω ÷ 1.0 m = 4.4 Ω m^{-1} $\rho = A \times$ gradient = 1.06×10^{-7} $m^2 \times 4.4$ Ω m^{-1} resistivity = 4.66×10^{-7} Ω m	**(1)** **(1)** **(1)** **(1)**	**4**
16(b)	temperature increases (with increasing current) resistance/resistivity would have increased (with temperature)	**(1)** **(1)**	**2**
16(c)	Precaution Explanation E.g. ensure good contact (e.g. tight croc clips); so pd across contact resistance doesn't make V results inaccurate E.g. Avoid pressing too hard on wire; as a deformation would affect cross-sectional area and therefore resistance e.g. ensure wire is straight so length measurement is accurate e.g ensure eyes perpendicular to scale to avoid parallax errors **Do not credit:** diameter of wire since area is not in the table repeat and average high resistance voltmeter keep temperature constant	**(1)** **(1)**	**2**
	Total for question 16		**8**

Question Number	Answer		Mark
17(a)*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Electrons/atoms move to higher energy levels / get excited They then move to lower energy levels (accept ground state) The energy from the move is given out in the form of a <u>photon</u> The energy levels are discrete **Or** only certain energy levels are possible The energy of the photon must be equal to the difference in energy levels **Or** $hf = E_2 - E_1$ There are only a limited number of energy differences and only a corresponding number of frequencies (looking for differences /changes **not** levels) (The marks above may be obtained from a suitably labelled diagram – but the order of excitation and de-excitation cannot be assumed for two marks just from the presence of both)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**6**
17(b)	Doppler (accept blue shift) The wavelength of the radiation is decreased / frequencies increases Star moving towards Earth or vice versa	**(1)** **(1)** **(1)**	**3**
17(c)	Light behaves as both particle and wave **Or** wave-particle duality	**(1)**	**1**
	Total for question 17		**10**

Question Number	Answer	Mark
18(a)	Oscillations/vibrations (of molecules) parallel to direction of propagation **(1)** **Or** oscillations parallel to direction of wave travel **Or** oscillations parallel to direction of energy transfer Produces compressions and rarefactions **(1)**	**2**
18(b)	Otherwise there wouldn't be a way of telling which bit of reflected sound originated with which bit of emitted sound **Or** so one returns before one emitted **(1)**	**1**
18(ci)	time (= 1÷16 Hz) = 0.063 (s) (at least 2 sf) **(1)**	**1**
18(cii)	Use of factor of 2 **(1)** Use of $v = s/t$ **(1)** distance = 48 m **(1)** (Use of 'show that' value gives 46m) <u>Example of calculation</u> 2 × distance = 1530 m s^{-1} × 0.063 s distance = 48 m	**3**
18(ciii)	A shorter time between clicks because the distance is shorter **Or** more frequent clicks allow rapid motion to be perceived. **Or** allow position to be determined precisely/accurately. **(1)**	**1**
18(d)	Speed in air lower than speed in water **(1)** So wavelength in air shorter than wavelength in water **Or** pulse length in air is shorter than pulse length in water **Or** attempt at numerical comparison of wavelength or pulse length **(1)** So bat echolocation will detect smaller targets **Or** detect smaller differences in position (conditional on MP2) **(1)** (Accept 'show more detail' or 'better resolution')	**3**
	Total for question 18	**11**

Question Number	Answer		Mark
19(a)	**When illuminated:** Use of the word <u>photon</u> photons/light cause emission of (photo)electrons Idea that (photo) electrons form a current photon energy greater than or equal to work function. **In darkness:** No photons so no photoelectrons released	**(1)** **(1)** **(1)** **(1)** **(1)**	**5**
19(b)	Use of $E = hf$ Conversion of eV to J One of the 4 values below correct $f = 5.2 \times 10^{14}$ Hz or $\lambda = 5.8 \times 10^{-7}$ m for caesium $f = 8.8 \times 10^{14}$ Hz or $\lambda = 3.4 \times 10^{-7}$ m for zinc Comment that Cs is in the visible range or Zn is ultraviolet – allow even without supporting calculation **Alternative method** Allow assumed max freq/min wavelength for visible light then, calculation of work function, quoted in eV, comparison with given work functions, conclusion: Use of (1); work fn (1), in eV (1), comparison (1) <u>Example of calculation</u> $f = \varphi \div h = (2.14 \times 1.6 \times 10^{-19})$ J $\div$ 6.63×10^{-34} J s $= 5.2 \times 10^{14}$ Hz for caesium $f = \varphi \div h = (3.63 \times 1.6 \times 10^{-19})$ J $\div$ 6.63×10^{-34} J s $= 8.8 \times 10^{14}$ Hz for zinc	**(1)** **(1)** **(1)** **(1)**	**4**
19(ci)	Maximum displacement of the wave **Or** maximum displacement from the mean **Or** maximum displacement from equilibrium	**(1)**	**1**
19(cii)	**Max 3** Size of the gap (in the soundtrack) determines the amount of light Amount of light determines number of photons Number of photons determines number of (photo) electrons (released by phototube) Number of electrons determines size of current (in the circuit) (Combining MP 1 and 2 by writing "size of the gap determines number of photons" scores 1 mark. Combining MP 2 and 3 by writing "the amount of light determines number of (photo) electrons" also scores 1 mark)	**(1)** **(1)** **(1)** **(1)**	**3**
	Total for question 19		**13**

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