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Mark Scheme (Results)
January 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 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.

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

Question Number	Answer	Mark
11	Indication that 500 W is 15% of incident radiation / Apply 15% efficiency to incident flux of 210 W m^{-2} (i.e. find useful input) (1) Use of radiation flux is power per unit area (1) Answer = 16 m^2 (1) [2.38 m^2 is the answer without applying 15% → 1 mark] <u>Example of calculation</u> Input power = (500 × 100)/15 = 3300 W Area = input power/radiation flux = 3300 W / 210 W m^{-2} = 16 m^2 OR (15/100) x 210 W m^{-2} = 31.5 W m^{-2} Area = 500 W / 31.5 W m^{-2} = 16 m^2	**3**
	Total for question 11	**3**

Question Number	Answer		Mark
12(a)	Use of $v = f\lambda$ f = 7.3 Hz [accept 7.3 s^{-1}, do not accept fractions] <u>Example of calculation</u> f = 330 m s^{-1} / 45 m f = 7.3 Hz	**(1)** **(1)**	**2**
12(b)	Diffraction / it diffracts **Either** an explanation of diffraction in general: Idea that the waves spread out (not bending) OR a diagram showing diffraction **OR** An explanation of why the tiger is heard: diffraction is significant for an obstacle (not a gap) of a size similar to the wavelength OR a diagram showing diffraction over a hill	**(1)** **(1)**	**2**
	Total for question 12		**4**

Question Number	Answer		Mark
13(a)	Tick in Ultrasound box only	**(1)**	**1**
13 (b)	A polarised wave is when the oscillations/vibrations are in one plane only which includes direction of travel (of the wave). **Or** A polarised wave is when the oscillations/vibrations are in one direction only which is perpendicular to the direction of travel (of the wave). **Or** Describes polarisation as a process where oscillations/vibrations in many planes are reduced to oscillations/vibrations in one plane [References to displacement are only acceptable in the context of varying displacement] Longitudinal waves oscillate/vibrate in one direction which is the direction of travel of the wave / parallel to the direction of travel of the wave.	**(1)** **(1)**	**2**
	Total for question 13		**3**

Question Number	Answer		Mark
14(a)	Resistance of parallel combination much less than resistance of V_1 (Therefore) voltage of parallel combination is much less than voltage of V_1 **Or** Identifies current (nearly) zero (because of resistance of V_1 very large) (So) p.d. across 10 Ω is zero by $V = IR$ (Credit for each marking point may be obtained by completing a calculation.)	**(1)** **(1)** **(1)** **(1)**	**2**
14(b)	Identifies resistance of parallel combination is 5 MΩ Use of resistors in parallel formula R = 10 MΩ	**(1)** **(1)** **(1)**	**3**
	Total for question 14		**5**

Question Number	Answer		Mark
15	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **MAX 6** Mention of energy levels (ignore electron shells) Electrons in atoms can only occupy certain (discrete) energy levels Ground state is the lowest energy/level electron(s)/atom can occupy Energy is transferred in the collisions Electrons/atoms move to higher level / become excited (when they gain energy) These electrons return (later) to lower level/ground state By emitting energy in the form of photons / reducing their energy by emitting photons Photons have a specific energy or frequency or reference to $E = hf$ or $E = E_2 - E_1$	 **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**Max 6**
	Total for question 15		**6**

Question Number	Answer	Mark
16(a)	State (V =) $E - Ir$ **(1)** Correct substitution **(1)** p.d. = 11V **(1)** **OR** Use of (V =) Ir to attempt to find lost volts **(1)** Subtraction from E **(1)** p.d. = 11V **(1)** **OR** Use of $E = I(R+r)$ to attempt to find R **(1)** Use of $V = IR$ with the value of R calculated **(1)** p.d. = 11V **(1)** <u>Example of calculation</u> $V = 12\text{ V} - 3 \times 10^{-3}\ \Omega \times 400\text{ A}$ p.d. = 10.8 V	**3**
16(b)	To prevent large energy dissipation / wire heating up / wire melting / large pd across the wires OR to allow a large current **(1)** Resistance of cable low **(1)** (cross-sectional) area large [Not surface area] **(1)** [Reverse argument in terms of a thin wire acceptable for all points]	**3**
	Total for question 16	**6**

Question Number	Answer	Mark
17(a)	(Ω =) V A^{-1} **OR** (Ω =) V/A **OR** $R = V / I$ [**OR** volt in alternative equivalent units divided by ampere in alternative equivalent units, as long as Ω isn't part of it] **(1)** [Units and quantities must not be mixed.]	**1**
17(b)(i)	Use of $R = V / I$ with values feasibly from the graph **(1)** R = 6.8 Ω to 8.0 Ω **(1)** (marks not awarded if using a gradient)	**2**
17(b)(ii)	resistance of metal remains constant **(1)** resistance of thermistor decreases (as p.d. increases) **(1)**	**2**
17(b)(iii)	(Increasing) current leads to temperature increase / leads to thermistor 'heating up' **(1)** More conduction electrons / more electrons released / more free electrons / more charge carriers / charge carrier density increased / n increases **(1)**	**2**
	Total for question 17	**7**

Question Number	Answer		Mark
18(a)	Use of sin $i \times v_2$ = sin $r \times v_1$ r = 90 º at critical angle critical angle = 75º Acceptable alternative: Use of $_1\mu_2 = v_1 / v_2$ State sin c = 1 / μ c = 75º (μ = 1.036, but look out for effects of rounding on calculated angle) <u>Example of calculation</u> sin c /1 = 1.96/2.03 c = 75º	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
18(b)	It will be reflected (back into the core) / totally internally reflected Reflection back into core may be shown on the diagram (allow e.c.f for value of c from (a))	**(1)**	**1**
18(c)	Most of the light will undergo repeated (total internal) reflection **Or** most light continually strikes at greater than the critical angle **Or** minimal light is lost through refraction Light reaches the bottom of the curtain **Or** Rays hitting the bottom will escape **Or** light hits the bottom at less than the critical angle	**(1)** **(1)**	**2**
	Total for question 18		**6**

Question Number	Answer		Mark
19(a)	Use of $W = QV$ Energy of electron = 1.6×10^{-14} (J) <u>Example of calculation</u> Energy = $1.6 \times 10^{-19} \times 100\ 000$ J Energy of electron = 1.6×10^{-14} J	**(1)** **(1)**	**2**
19(b)	Use of energy = power × time Energy = 2.88×10^{7} (J) <u>Example of calculation</u> Energy = $1000 \times 8 \times 3600$ Energy = 2.88×10^{7} J	**(1)** **(1)**	**2**
19(c)	**Max 2** eV is very much smaller than Joule kW h is very much bigger than Joule in these units, answers more easily obtained from information available OR answers can be found without conversions	 **(1)** **(1)** **(1)**	**Max 2**
	Total for question 19		**6**

Question Number	Answer		Mark
20(a)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Reference to photons (may be descriptive, e.g. quantum of energy / light arrives in small packets / light particles …) Energy of photon greater than or equal to work function (of zinc) / $hf \geq \varphi$ Results in electron being emitted So (electroscope) loses charge / charge decreases (and leaf falls)	 **(1)** **(1)** **(1)** **(1)**	**4**
20(b)	Photon energy (for visible light) is less than the work function OR frequency (of visible light) less than threshold frequency	**(1)**	**1**
20(c)	Use of $c = f\lambda$ to find frequency (award if hc/λ used) Use of $hf = \Phi + ½ m v^2$ to find KE Use of ke equation with m_e $v = 8.20 \times 10^5$ m s^{-1} <u>Example of calculation</u> KE = $(6.63 \times 10^{-34} \times 3 \times 10^8)/200 \times 10^{-9} - 6.88 \times 10^{-19}$ KE = 3.07×10^{-19} J $v = \sqrt{}(2 \times 3.07 \times 10^{-19})/9.11 \times 10^{-31}$ $v = 8.20 \times 10^5$ m s^{-1}	**(1)** **(1)** **(1)** **(1)**	**4**
20(d)	No change Photon energy doesn't change (with distance) **Or** photon energy depends (only) on frequency/wavelength	**(1)** **(1)**	**2**
	Total for question 20		**11**

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Question Number	Answer		Mark
21(a)	Units of LHS m s^{-1} (1) Units of T = kg m s^{-2} (1) Units of μ = kg m^{-1} (1)	**(1)** **(1)** **(1)**	**3**
21(b)(i)	Waves travel in both directions along wire **OR** reference to being reflected (not bounce) Waves superpose / interference effect / superposition occurs (not superimpose) Producing nodes and antinodes **OR** node is produced where waves are 180º out of phase / antiphase **OR** antinode is produced where waves are in phase **OR** node produced at a point of destructive interference **OR** antinode produced at a point of constructive interference **OR** produces points/ positions of constructive interference and points/ positions of destructive interference	**(1)** **(1)** **(1)**	**3**
21(b)(ii)	$\lambda = 4$ m	**(1)**	**1**
21(b)(iii)	Substitution into the formula ignoring powers of ten $v = 173$ m s^{-1} <u>Example of calculation</u> $v = \sqrt{(150 \text{ N}/ 0.005 \text{ kg m}^{-1})}$ $v = 173$ m s^{-1}	**(1)** **(1)**	**2**

21(b)(iv)	Some of the marks may be gained from diagrams which show length remaining constant. Nodes and antinodes do not need to be labelled. Assume a sequence of diagrams shows increasing frequency. • Wave speed const **(1)** • (As frequency increases) wavelength decreases **(1)** Then **max 3** from • At most frequencies there is no standing wave / as frequency changes from a standing wave the wave no longer occurs / Standing waves only occur at some frequencies **(1)** • At higher frequencies there are more nodes / antinodes / loops (Not 'more waves') **(1)** • There is always a node at either end **Or** No of nodes = no of antinodes plus one **(1)** • Amplitude is less if there is a greater number of nodes **(1)** • Length = n $\lambda/2$ / after first standing wave, they occur when frequency x 2, x 3, x 4 etc / for frequency nf_0 **(1)**	**Max 4**
	Total for question 21	**13**

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