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Mark Scheme (Results)

January 2014

IAL Physics (WPH02/01)

Unit 2: 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] [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. '<u>resonance</u>'
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:

<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] 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	 ✓ ✓ ✓	 **3**

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

Question Number	Answer		Mark
11	To ensure a (very) small current **Or** to ensure zero current **Or** otherwise there would be a current So the lost volts = (nearly) zero **Or** so $Ir = 0$ **Or** because otherwise there would be lost volts **Or** $V = \mathcal{E} R_{\text{Voltmeter}} / (R_{\text{Voltmeter}} + r)$ (Accept $V = \mathcal{E} R / (R + r)$) If $R_{\text{Voltmeter}} >> r$, $V = \mathcal{E}$	**(1)** **(1)** **(1)** **(1)**	**2**
	Total for Question 11		**2**

Question Number	Answer		Mark
12(a)	Use of $n = \sin i / \sin r$ $n = 1.5$ <u>Example of calculation</u> $n = \sin 40° \div \sin 25°$ $n = 1.521$	**(1)** **(1)**	**2**
***12(b)**	**(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate)** **Max 3** marks for criticism and **Max 3** marks for improvement **Criticism:** Comment on limitations of precision of measurements, e.g. protractor to 1°, thickness of ray, thickness of pencil line Comment on the high uncertainty Comparison of precision of calculated value to that of the values in the table Comment on use of single measurement **Improvement:** Use larger angle (to reduce percentage uncertainty) Use a laser (with a narrower beam than the ray box) Take measurements over a range of angles Determine mean value of refractive index OR use graph of sin i vs sin r	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**4**
	Total for Question 12		**6**

Question Number	Answer		Mark
13(a)	Unpolarised – oscillations/vibrations in many directions … Polarised – oscillations/vibrations in single direction … … perpendicular to direction of propagation **Or** Unpolarised – oscillations/vibrations in many planes … Polarised – oscillations/vibrations in single plane … … plane includes direction of propagation	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
13(b)	**Max 3 Marks** Plane of polarisation of lens must be aligned at 90 degrees to plane of polarisation of reflected light Glare / reflected light is blocked/absorbed (by the lens) Light from below surface is (almost) unpolarised (Half) the light from below will pass through the lens OR only some of the light from below the surface is blocked/absorbed	**(1)** **(1)** **(1)** **(1)**	**3**
	Total for Question 13		**6**

Question Number	Answer		Mark
14(a)	Frequency from graph = 1000 Hz (accept values between 1000 and 1010 Hz) Use of wavespeed = frequency × wavelength Wavelength = 0.33 (m) (answer to 2 sf) <u>Example of calculation</u> $\lambda = v \div f$ $\lambda = 330 \text{ m s}^{-1} \div 1000 \text{ Hz}$ $\lambda = 0.33 \text{ m}$	**(1)** **(1)** **(1)**	**3**
14(b)(i)	<u>Waves</u> meeting a gap or obstacle (not through obstacle) Spread out (ignore bend)	**(1)** **(1)**	**2**
14(b)(ii)	Male voice has greater wavelength Greater wavelengths diffract more **Or** Diffraction most when wavelength approx equal to gap size Female wavelength about a third of gap size / male wavelength very close / female component of approximately gap size in spectrum small	**(1)** **(1)** **(1)** **(1)**	**2**
	Total for Question 14		**7**

Question Number	Answer		Mark
15(a)	Use of $R = \rho l/A$ $A = 1.3 \times 10^{-11}$ m^2 <u>Example of calculation</u> $A = \rho l/R$ $A = 3.5 \times 10^{-5}\ \Omega$ m $\times$ 0.02 m / 55 000 Ω $A = 1.3 \times 10^{-11}$ m^2	**(1)** **(1)**	**2**
15(b)	Use of $V = IR$ Use of $I = nAvq$ (allow ecf for A) Correct use of factor of 2 (factor of 2 may be introduced at any point) v = 31 m s^{-1} (use of 'show that' value 1×10^{-11} m^{2}gives answer 39 m s^{-1}) <u>Example of calculation</u> $I = V \div R$ I = 6.0 V ÷ 55 000 Ω = 1.1×10^{-4} A For 100%, 1.1×10^{-4} A = 3.5×10^{24} m^{-3} × 1.3×10^{-11} m^2 × v × 1.6×10^{-19} C $v = 1.1 \times 10^{-4}$ A ÷ (0.5 × 3.5×10^{24} m^{-3} × 1.3×10^{-11} m^2 × 1.6×10^{-19} C)	**(1)** **(1)** **(1)** **(1)**	**4**
15(c)	Softer pencil would make a thicker shape **Or** make a shape with a larger cross-sectional area **Or** has more charge carriers Resistance would be lower	**(1)** **(1)**	**2**
	Total for Question 15		**8**

Question Number	Answer		Mark
16(a)	Packet / package / quantum of …(energy / light / e-m radiation / light energy / e-m energy – something relevant – no mark simply for packet …) … <u>electromagnetic</u> radiation / <u>electromagnetic</u> energy (independent mark)	**(1)** **(1)**	**2**
16(b)(i)	An allowed/possible/specific/discrete quantity of energy for (an electron in) the atom	**(1)**	**1**
16(b)(ii)	(Photon is emitted when) an electron moves to a lower energy level The lowest frequency photon will be emitted for a transition from level 5 to level 4 Use of difference in energy levels in eV Use of $W = QV$ for conversion to Joule Use of $E = hf$ Frequency = 4.1×10^{13} Hz <u>Example of calculation</u> difference in energy levels = (−0.38 eV) − (−0.55 eV) = 0.17 eV $W = 0.17 \times 1.6 \times 10^{-19}$ J $f = 0.17 \times 1.6 \times 10^{-19}$ J ÷ 6.63×10^{-34} J s = 4.1×10^{13} Hz	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**6**
	Total for Question 16		**9**

Question Number	Answer		Mark
*17	**(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate)** • Photons (from incident light) • Photons/light/e-m radiation cause emission of electrons from surface of metal • Photon has energy hf ($E = hf$ not sufficient alone, but link of E to photon may follow on by implication from previous writing) • Emission only if photon energy greater than (or equal to) φ (work function) **Or** φ (work function) is minimum energy required for emission of electrons • ½ mv^2 is the kinetic energy of the emitted electron • (It is max because) some energy may be transferred to the metal (accept description of more energy required to reach surface if atom/electron not at the surface)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**6**
	Total for Question 17		**6**

Question Number	Answer		Mark
18(a)	Increase in temperature because of increased lattice ion vibrations **Max 2 Marks** Potential difference causes a current **Or** Potential difference causes electrons to be given a drift velocity Electrons have (more) kinetic energy **Or** Electrons have more frequent collisions with lattice ions (More) energy is transferred when electrons collide with lattice ions (accept atoms) Energy dissipation due to (work done against) resistance (may refer to I^2R)	**(1)** **(1)** **(1)** **(1)** **(1)**	**3**
18(b)(i)	Use of $P = IV$ P = 23 (W) (2 sf) <u>Example of calculation</u> P = 1.95 A × 11.6 V = 22.6 W	**(1)** **(1)**	**2**
18(b)(ii)	Use of $W = IVt$ (allow ecf) W = 9500 (J) (2 sf) <u>Example of calculation</u> W = 1.95 A × 11.6 V × 7× 60 s = 9500 J	**(1)** **(1)**	**2**
18(b)(iii)	Use of efficiency equation (allow ecf) Use of total energy = thermal energy + light energy Efficiency = 0.18 **Or** Efficiency = 18% <u>Example of calculation</u> Useful energy (light) = 9500 J – 7800 J = 1700 J Efficiency = 1700 J ÷ 9500 J = 0.18	**(1)** **(1)** **(1)**	**3**
18(b)(iv)	Sensible comment, e.g. some energy transferred by heating glass/block/surroundings/air (not sound)	**(1)**	**1**
	Total for Question 18		**11**

Question Number	Answer		Mark
19(a)	The vibration generator is vibrating along the axis of the spring **Or** the displacements in the photograph are all along the axis of the spring **Or** there are compressions and rarefactions The displacement/vibration is parallel to the direction of propagation of the waves produced by the generator **Or** The displacement/vibration is the same as the direction of travel of the waves	**(1)** **(1)**	**2**
19(b)	A point with zero amplitude **Or** a point where the displacement is always zero	**(1)**	**1**
19(c)	Waves from the generator are reflected at the end **Or** waves are travelling in both directions When the two waves meet they superpose/interfere Producing points where the waves are in phase and points where they are in antiphase **Or** producing points of zero amplitude and points of maximum amplitude (producing nodes and antinodes not sufficient as nodes have been identified already)	**(1)** **(1)** **(1)**	**3**
19(d)	Determines wavelength from photograph (0.14 m) Use of velocity = frequency x wavelength Velocity = 4.8 (m s^{-1}) [max 1 mark only if wrong wavelength] <u>Example of calculation</u> $\lambda = 0.72\text{ m} \div 5$ $v = f\lambda$ $v = 34\text{ Hz} \times 0.14\text{ m}$ $v = 4.8\text{ m s}^{-1}$	**(1)** **(1)** **(1)**	**3**
19(e)	Use of velocity = distance / time Divides by 42 to find the time for the pulse to travel one length of the spring / multiplies length by 42 to find total distance / applies factor of 2 correctly Velocity = 4.9 m s^{-1}	**(1)** **(1)** **(1)**	**3**
19(f)	**Max 3, at least 1 from each of similarities and differences** **Similarities** Both are standing/stationary waves Both have a node at either end The wave velocity in the second is 0.36 m x 14 Hz = 5.0 m s^{-1}, so the velocity is about the same **Differences** In the first the length of the spring is 5 wavelengths but here it is 2 wavelengths **Or** the wavelength is longer for the second spring **Or** first wave has more nodes/antinodes than second wave **Or** the nodes/antinodes are closer together in the first photograph Second wave is a transverse wave (not just 'not longitudinal') **Or** the displacement is perpendicular to the direction of propagation of the waves **Or** the displacement is perpendicular to the spring axis **Or** first wave has compressions and rarefactions (and second wave doesn't)	**(1)** **(1)** **(1)** **(1)** **(1)**	**3**
	Total for Question 19		**15**

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