Mark Scheme (Results)

January 2021

Pearson Edexcel International Advanced Subsidiary Level in Physics (WPH12)
Paper 1: Waves and Electricity

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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] [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] ✓

Example of answer:

3

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	**B is the correct answer as the base units for power are kgm^2s^{-3}** A is not the correct answer as the newton is not a base unit C is not the correct answer as the joule is not a base unit D is not the correct answer as the ampere does not appear in kgm^2s^{-3}	**(1)**
2	**C is the correct answer as inverting (1/Y + 1/Z) leads to YZ / (Y + Z)** A is not the correct answer as the section (1/Y + 1/Z has not been inverted) B is not the correct answer as this considers resistor X as a parallel resistor D is not the correct answer as this considers resistor X as a parallel resistor	**(1)**
3	**D is the correct answer as the shorter the pulse, the shorter the time over which reflections are received.** A is not the correct answer as only some of the ultrasound is reflected B is not the correct answer as the air is less dense than body tissues C is not the correct answer as higher resolution is gained with smaller λ	**(1)**
4	**C is the correct answer as the photoelectric effect can only be explained using the photon model of light.** A is not the correct answer as diffraction is demonstrated using waves B is not the correct answer as the Huygen's construction is demonstrated using waves D is not the correct answer as plane polarisation is demonstrated using waves	**(1)**
5	**D is the correct answer as $V = (-r)I + \varepsilon$ when in a $y=mx + c$ format.** A is not the correct answer as the area beneath the graph does not represent energy dissipated in the cell B is not the correct answer as the gradient of the graph is $-r$ C is not the correct answer as the graph is not a straight line through the origin	**(1)**
6	**C is the correct answer as $\varepsilon = I (R + r)$** A is not the correct answer as this does not include the effect of r B is not the correct answer as this does not include the effect of R D is not the correct answer as the two resistances are subtracted instead of added.	**(1)**
7	**B is the correct answer as the time period is 0.4 seconds, and $f = 1/T$** A is not the correct answer as the amplitude is 10cm. C is not the correct answer as the time period is 0.4 seconds D is not the correct answer as the wavelength cannot be determined from a graph of displacement against time.	**(1)**
8	**D is the correct answer as 45° is beyond the critical angle, so total internal reflection takes place** A is not the correct answer as there will also be some reflection at this angle B is not the correct answer as there will also be some refraction at this angle C is not the correct answer as there will be no refraction at this angle.	**(1)**

9	**B is the correct answer as the momentum of a photon is h/λ** A is not the correct answer as momentum is mv C is not the correct answer as it is not the speed of light, but the speed of the electron. D is not the correct answer as h is a constant.	**(1)**
10	**A is the correct answer as current = total charge / time** B is not the correct answer as the charge of an electron is incorrectly inserted C is not the correct answer as the time is incorrectly inserted D is not the correct answer as the time and charge of an electron have been swapped around	**(1)**

Question Number	Answer		Mark
11	Use of $I = nqvA$ (using dimensionally-correct A)	(1)	
	$v = 7.5 \times 10^{-4}$ m s^{-1}	(1)	**2**
	Example of calculation $A = \pi r^2 = \pi\ (0.40 \times 10^{-3}\ \text{m})^2 = 5.0 \times 10^{-7}\ \text{m}^2$ $v = \frac{I}{nqA} = \frac{5.1\ \text{A}}{(8.5 \times 10^{28}\ \text{m}^{-3})(1.6 \times 10^{-19}\text{C})(5.0 \times 10^{-7}\text{m}^2)}$ $v = 7.5 \times 10^{-4}$ m s^{-1}		
	Total for Question 11		**2**

Question Number	Answer		Mark
12	Position A: Constructive (superposition)	(1)	
	Position B: Destructive (superposition)	(1)	
	Constructive is when: waves are in phase **Or** path difference is λ	(1)	
	Destructive is when: waves are in antiphase **Or** path difference is 3λ / 2	(1)	**4**
	(MP3 and MP4 are not dependent upon MP1 and MP2) (MP3 – accept phase difference of 2π radians or 360°) (MP4 – accept phase difference of π radians or 180°). (Phase difference must refer to an angle, path difference to a distance) (MP3 – allow path difference of nλ) (MP4 – allow path difference of λ/2 or (n + ½)λ) (MP4 – do not allow out of phase) (Ignore references to nodes and antinodes)		
	Total for Question 12		**4**

Question Number	Answer	Mark
13 (a)	Use of $R = V/I$ **Or** Equates ratio of resistances to ratio of p.d.s (1) $R = 1300\ \Omega$ (1) Example of calculation Whole circuit current = $V/R = 1.19\ V / 5000\ \Omega = 2.38 \times 10^{-4}$ A R (of LDR) = $V/I = (0.31\ V) / (2.38 \times 10^{-4}\ A) = 1300\ \Omega$	**2**
13(b)	Calculates p.d. across fixed resistor as 1.497V (1) Difference between 1.50 and 1.497 is less than 0.01V (1) **OR** Calculates p.d across the LDR as 0.003 V (1) 0.003 < 0.01V (1) **OR** As resistance of the LDR decreases, the voltmeter reading increases (1) p.d. across the LDR becomes less than 0.01 V (1) **OR** Ratio of resistor resistance to LDR resistance becomes very high (1) p.d. across the LDR becomes less than 0.01 V (1) (Do not allow MP1 for use of V = IR with current value calculated in (a)) (3rd or 4th methods – allow "there is hardly any p.d. across the LDR") (For all MP, allow "resolution of the voltmeter" for "0.01V") (For MP1 via 3rd method, allow "p.d. across (fixed) resistor increases" for "the voltmeter reading increases")	**2**
	Total for Question 13	**4**

Question Number	Answer		Mark
14	For the electron (in the atom) to move from −13.6eV to −1.5eV requires 12.1eV	(1)	
	0.2eV/ remaining (kinetic) energy left for the (incoming) electron	(1)	
	Idea that <u>energy</u> of a photon is transferred to a single electron **Or** Idea that photon can only excite an electron if it matches the energy difference between levels **Or** Idea that photons give all of their energy (or none at all)	(1)	
	Photon energy is not exactly 12.1eV so electron/atom remains at the −13.6eV level **Or** There is no transition equivalent to 12.3 eV **Or** There is no −1.3 eV energy level	(1)	**4**
	(Ignore references to work function or photons being emitted) (MP1 – award this mark if 12.1eV is seen) (MP3 – do not award simply for saying "one photon interacts with one electron") (MP4 – Award if candidates make it clear that 12.1eV is not equal to 12.3eV in an argument to explain why photons cannot produce the change in energy levels for the electron)		
	Total for Question 14		**4**

Question Number	Answer		Mark
15(a)	Change of direction (of a ray of light) Due to change in speed/density/medium/material/RI	(1) (1)	**2**
	(MP1 – do not allow "bending", but allow "deviation")		
15(b)	Use of trigonometry to correctly determine either i or r Use of $n_1 \sin \theta_1 = n_2 \sin \theta_2$ using calculated angles Refractive index = 1.3	(1) (1) (1)	**3**
	(MP1 – Need to see working shown, as the r angle from the diagram is close to 43° with a protractor) (MP2 – Award if using $n = \sin i / \sin r$) (MP2 – Both angles need to be correct to award this mark)		
	<u>Example of calculation</u> Tan i = (1.8 cm / 3.0 cm), i = 31° Tan r = (3.7 cm / 4.0 cm), r = 43° $n_1 \sin \theta_1 = n_2 \sin \theta_2$ so $n_1 \sin 31° = 1.00 \sin 43°$ $n_1 = 1.32$		
	Total for Question 15		**5**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>*16</td><td>
This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>IC points</th><th>IC mark</th><th>Max linkage mark</th><th>Max final mark</th></tr>
<tr><td>6</td><td>4</td><td>2</td><td>6</td></tr>
<tr><td>5</td><td>3</td><td>2</td><td>5</td></tr>
<tr><td>4</td><td>3</td><td>1</td><td>4</td></tr>
<tr><td>3</td><td>2</td><td>1</td><td>3</td></tr>
<tr><td>2</td><td>2</td><td>0</td><td>2</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>
The following table shows how the marks should be awarded for structure and lines of reasoning.
<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained line of reasoning</th></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>
Indicative content

For filament bulb, resistance increases (as p.d. increases)
Or For filament bulb, p.d. increases at a greater rate than current
Or rate of increase of current decreases.
Increased temperature leads to increased vibration of ions/atoms/lattice
Increased rate of collision between electrons and ions/atoms/lattice
For a thermistor, resistance decreases (as p.d. increases)
Or For a thermistor, current increases at a greater rate than p.d.
Or rate of increase of current increases
Increased number of conduction electrons
$I = nAqv$, so current increases.

(For IC1 & IC4 accept symbols for p.d. and current)
(Ignore references to the gradient of the graph as $1/R$)
</td><td>6</td></tr>
<tr><td></td><td>Total for Question 16</td><td>6</td></tr>
</table>

Question Number	Answer	Mark
17(a)	Use of $v = f\lambda$ (1) Use of $E = hf$ (1) Converts work function from eV to J (1) Use of $hf = \Phi + \frac{1}{2} mv^2_{max}$ (1) $v_{max} = 4.5 \times 10^6$ m s^{-1} (1) (MP4 can only be awarded if values substituted are valid energy and mass values) <u>Example of calculation</u> $v = f\lambda$, 3.00×10^8 m s^{-1} = f × $(20 \times 10^{-9}$ m), f = 1.50×10^{16} Hz $E = hf$ = $(6.63 \times 10^{-34}$ Js) $(1.50 \times 10^{16}$ Hz) = 9.95×10^{-18} J Work function Φ = (3.68 eV) $(1.60 \times 10^{-19}$ J/eV) = 5.89×10^{-19} J $hf = \Phi + \frac{1}{2} mv^2_{max}$, 9.95×10^{-18} J = 5.89×10^{-19} J + $\frac{1}{2} mv^2_{max}$ $\frac{1}{2}$ $(9.11 \times 10^{-31}$ kg) $v^2_{max} = 9.36 \times 10^{-18}$ J $v_{max} = 4.53 \times 10^6$ m s^{-1}	**5**
17(b)	Increasing intensity leads to more photons/electrons (1) But intensity does not affect the speed/ KE (of electrons) (1) Increasing λ leads to a decrease in photon/light energy (1) Leads to decrease in speed/ KE (for electrons), so student incorrect (1) (MP1 – Allow equations with arrows correctly indicating increased and decreased components)	**4**
	Total for Question 17	**9**

Question Number	Answer		Mark
18(a)	Light directed through one polarising filter	(1)	
	Filter is rotated until no light passes through **Or** filter is rotated and light changes intensity	(1)	**2**
	(Answers involving use of more than one polarising filter can only potentially score MP2)		
18(b)(i)	Distance between (adjacent) slits **Or** grating spacing **Or** line spacing **Or** slit spacing **Or** $\frac{1}{lines\ per\ m}$	(1)	**1**
18(b)(ii)	Use of $\tan\theta = \frac{\text{distance from central maximum to first order}}{\text{grating to screen distance}}$	(1)	
	Use of $n\lambda = d\sin\theta$	(1)	
	number of lines per mm = 950	(1)	**3**
	(MP1 – award if $\sin\theta$ calculated from Pythagoras) (Use of Young's Double Slit equation scores 0)		
	Example of calculation $\tan\theta$ = 1.61m / 2.74m, θ = 30.4° $d = n\lambda / \sin\theta$ = (1)(532 × 10^{-9} m) / sin (30.4°) d = 1.05 × 10^{-6} m number of lines per m = 1 / 1.05 × 10^{-6} m = 9.52 × 10^{5} m^{-1}. number of lines per mm = 952		
18(b)(iii)	Measuring distance from from first order maxima on one side of the central maxima to the first order maxima on the other side	(1)	
	Increasing distance from diffraction grating to screen	(1)	
	It would decrease <u>percentage</u> uncertainty	(1)	**3**
	(MP3 is dependent upon awarding MP1 or MP2)		
	Total for Question 18		**9**

Question Number	Answer	Mark
19(a)	Power supply, ammeter, variable resistor and nichrome wire all in series (1) Voltmeter in parallel across nichrome wire (1)	**2**
19(b)(i)	Gradient calculated **Or** value of p.d. read off for a corresponding length (1) Gradient uses more than half of the graph **Or** value of p.d. used is greater than 2.0V **Or** value of length used is greater than 0.5m (1) Use of $R = \rho l/A$ **and** $R = V / I$ **Or** Use of ρ = (gradient × A) / I (1) $\rho = 1.1 \times 10^{-6}\ \Omega$m (1) (MP1 – Values read off graph need to be within ½ a square) (MP1 – Gradient should be in the range 4.1 – 4.2 Vm^{-1}) <u>Example of calculation</u> Gradient = V / l = (4.15 V /1.00 m) = 4.15 Vm^{-1} $V / l = \rho I/A$, so ρ = (gradient × A) / I = (4.15 Vm^{-1} × 5.31 × 10^{-8} m^2) / 0.200 A = 1.10 × $10^{-6}\ \Omega$m	**4**
19(b)(ii)	V value read from graph = 3.1V (1) Use of $P = VI$ (1) P = 0.62 W (1) (MP1 – allow use of resistivity equation with answer from (i) used to calculate V or R) (MP2 – allow combination of equations e.g. $R = V/I$ followed by $P = I^2R$) (MP3 – allow variation of value if using resistivity value that rounds to 1.1× $10^{-6}\ \Omega$m from (i)) <u>Example of calculation</u> $P = VI$ = (3.1 V × 0.200 A) = 0.62 W	**3**
	Total for Question 19	**9**

Question Number	Answer	Mark
20(a)	Use of $A = 4\pi r^2$ (1) Use of $I = P/A$ to calculate I (1) $I = 1.3$ W m^{-2} < 4.5 W m^{-2} so not dangerous (1) **OR** Use of $A = 4\pi r^2$ (1) Use of $I = P/A$ to calculate A (1) $r = 0.13$ m < 0.25 m so not dangerous (1) (For MP2 via second method, look for area of 0.22 m^2) Example of calculation $A = 4\pi$ (0.25 m) $^2 = 0.79$ m^2 $A = P/I$ so 0.79 m^2 = 1.00 W / I , so $I = 1.27$ W m^{-2}	**3**
20(b)	Use of $E = hf$ (1) Conversion from J to eV (1) Energy per photon = 3.7×10^{-6} (eV) (1) Example of calculation $E = hf = (6.63 \times 10^{-34}$ Js) × (902×10^{6} Hz) = 5.98×10^{-25} J Energy per photon (in eV) = (5.98×10^{-25} J) / (1.60×10^{-19} J eV^{-1}) = 3.74×10^{-6} eV.	**3**
20(c)	Use of $P = E/t$ for kettle (1) Converts kWh to J for electricity usage **Or** converts J to kWh for kettle usage (1) Percentage = 0.61% so student is correct **Or** states that 150,000 J is less than 1% of 2.47×10^7 J so student is correct (1) (Kettle energy in kW h is 0.042) Example of calculation $E = P \times t$ (for kettle) = 1200 W × 125 s = 150,000 J Electricity usage = 6.85 kWh = 6.85 ×1000 W x 3600 s = 2.47×10^7 J Kettle's percentage of daily usage = [(150,000J) / (2.47×10^7 J)] × 100 Percentage = 0.61%	**3**
	Total for Question 20	**9**

Question Number	Answer		Mark
21(a)(i)	Recognises that wavelength = 2 × length of recorder **Or** recognises that length of recorder = $\lambda/2$ **Or** see that λ used is 47.2 cm / 0.472 m	(1)	
	Use of $v = f\lambda$ with $v = 330\ \text{m s}^{-1}$	(1)	
	$f = 700$ Hz	(1)	**3**
	Example of calculation Wavelength = 2 × length of recorder = 2 × 0.236 m = 0.472m $v = f\lambda$ so $f = 330\ \text{m s}^{-1} / 0.472$ m = 699 Hz		
21(a)(ii)	To keep same frequency, wavelength would need to increase	(1)	
	So length of recorder needs to increase **Or** so length of air column needs to increase	(1)	
	This is achieved by sliding the recorder sections further apart **Or** this is achieved by loosening the sections of the recorder	(1)	**3**
	(Do not award MP2 or MP3 if clearly linked to a decrease in wavelength)		
21(b)	See $v = f\lambda$ and $v = \sqrt{(T/\mu)}$	(1)	
	Combines equations to show that $f \propto \sqrt{T}$ **or** $T = \text{k}f^2$ **Or** recognises that $T_2/T_1 = (f_2/f_1)^2$ **Or** see $\frac{(440)^2-(432)^2}{(432)^2}$	(1)	
	Percentage increase in T is 3.7%	(1)	**3**
	Example of calculation $f\lambda = \sqrt{(T/\mu)}$ so $T = \text{k}f^2$ $T_2/T_1 = (f_2/f_1)^2$ so $T_2/T_1 = (440\ \text{Hz}/432\ \text{Hz})^2 = 1.037$ Percentage increase in T is 3.7%		
	Total for Question 21		**9**