Mark Scheme (Results)

October 2019

Pearson Edexcel International Advanced Level
In Physics (WPH12) Paper 01
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] **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.

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 is the correct answer as the resistance of both listed components decreases as the applied potential difference increases.** A is not the correct answer as the resistance of an ohmic conductor remains constant when the applied potential difference increases. B is not the correct answer as the resistance of a filament lamp increases when the applied potential difference increases. D is not the correct answer as the resistance of a filament lamp increases when the applied potential difference increases.	**(1)**
2	**A is the correct answer as this represents the current in the internal resistance multiplied by the p.d. across the internal resistance.** B is not the correct answer as this is the power dissipated by the external resistance C is not the correct answer as this is the power dissipated by the whole circuit. D is not the correct answer as this equation combines the p.d. across the external resistance with the value for the internal resistance – as a result, it does not represent the power of any of the components in the circuit	**(1)**
3	**B is the correct answer as $n_{water} \times v_{water} = n_{glass} \times v_{glass}$** A is not the correct answer as $n_{water} \times v_{water} = n_{glass} \times v_{glass}$ C is not the correct answer as $n_{water} \times v_{water} = n_{glass} \times v_{glass}$ D is not the correct answer as $n_{water} \times v_{water} = n_{glass} \times v_{glass}$	**(1)**
4	**B is the correct answer as increasing light intensity increases the number of electrons released per second (N), but does not affect the maximum kinetic energy of each released electron (E_k)** A is not the correct answer as the graphs show no effect on N and an effect on E_k C is not the correct answer as the graphs show an effect on E_k D is not the correct answer as the graphs show no effect on N	**(1)**
5	**A is the correct answer $v = I/nAq$ – doubling d quadruples A, and with n doubling also, the denominator is 8 times larger** B is not the correct answer as A is quadrupled and n is doubled (factor of 8 overall) C is not the correct answer as A is quadrupled and n is doubled (factor of 8 overall) D is not the correct answer as A is quadrupled and n is doubled (factor of 8 overall)	**(1)**
6	**B is the correct answer as polarisation only occurs in transverse waves** A is not the correct answer as diffraction can be demonstrated for all waves C is not the correct answer as refraction can be demonstrated for all waves D is not the correct answer as superposition can be demonstrated for all waves	**(1)**
7	**D is the correct answer as efficiency is the useful power output (250W) divided by the total power input (Intensity x Area).** A is not the correct answer as this is (Power × Area) / Intensity B is not the correct answer as this is Intensity / (Power × Area) C is not the correct answer as this is the reciprocal of the efficiency equation	**(1)**
8	**D is the correct answer as $P = V^2/R$, so for a constant resistance, doubling V results in P quadrupling.** A is not the correct answer as this suggests that P is constant regardless of V B is not the correct answer as this suggests that P is directly proportional to V C is not the correct answer as this suggests that doubling P quadruples V	**(1)**

9	**B is the correct answer as 7λ/4 represents 3.5 radians, which is 1.5π radians out of phase.** A is not the correct answer as 3λ/2 represents 3π radians which is antiphase C is not the correct answer as 3λ represents 6π radians which is in phase D is not the correct answer as 7λ/2 represents 7π radians, which is antiphase	**(1)**
10	**B is the correct answer as $n\lambda = d\sin\theta$, and reducing d would increase $\sin\theta$ if n and λ remain the same.** A is not the correct answer as this would result in the maxima being closer together C is not the correct answer as this would have no effect on the distance D is not the correct answer as this would result in the maxima being closer together	**(1)**

Question Number	Answer	Mark
11	Use of $E = hf$ (1) Converts J to eV (1) Transition from (−) 0.54eV to (−) 0.85eV (1) **Example of calculation** $E = hf = (6.63 \times 10^{-34}$ Js$) \times (7.48 \times 10^{13}$ Hz$) = 4.96 \times 10^{-20}$ J 4.96×10^{-20} J / $(1.60 \times 10^{-19}$ J eV$^{-1}) = 0.31$ eV	**(3)**
	Total for question 11	**3**

Question Number	Answer	Mark
12a	Use of $p = mv$ for electron ($m = 9.11 \times 10^{-31}$ kg used) (1) Use of $\lambda = h/p$ (1) Speed of car = 1.5×10^{-26} (m s^{-1} which is very small) so student suggestion is correct. (1) **Example of calculation** p for electron = $(9.11 \times 10^{-31}$ kg$)$ $(1.5 \times 10^{7}$ m s$^{-1}) = 1.37 \times 10^{-23}$ kgms^{-1} λ for electron = $(6.63 \times 10^{-34}$ Js$)$ / $(1.37 \times 10^{-23}$ m$)$ = 4.8×10^{-11} m. For the car, 4.8×10^{-11} m = $(6.63 \times 10^{-34}$ Js$)$ / (900 kg) v $v = 1.5 \times 10^{-26}$ m s^{-1}	**(3)**
12b	The car is not a single particle **Or** The car does not behave like a wave/particle **Or** de Broglie equation has only been demonstrated for microscopic particles (1)	**(1)**
	Total for question 12	**4**

Question Number	Answer		Mark
13a	Use of $V=W/Q$ $W = 7.92 \times 10^5$ J **<u>Example of calculation</u>** $W = V \times Q$ = 22 x 36,000 = 792,000 J	(1) (1)	**(2)**
13bi	Use of speed = distance/time Time = 0.45 s (Accept 7.5×10^{-3} minutes or 1.25×10^{-4} hours) **<u>Example of calculation</u>** 16 km hr^{-1} = 16,000 m/ 3,600 s= 4.4 m s^{-1} Time = distance / speed = 2.0 m / 4.4 m s^{-1} = 0.45 seconds.	(1) (1)	**(2)**
13bii	Use of $I = Q / t$ Calculates total charge used in 2.00 m Number of electrons = 4.2×10^{19} (e.c.f. from (i)) **OR** Use of speed = distance / time Calculates total charge used in 2.00m Number of electrons = 4.2×10^{19} (no e.c.f. required from (i) for this method) **<u>Example of calculation</u>** $I = Q / t$ = 36,000 C / (40 x 60) s = 15 A Total charge used in 2.00m = I × t = 15 A x 0.45 s = 6.75 C number of electrons = 6.75 C / 1.6×10^{-19} C = 4.2×10^{19}	(1) (1) (1) (1) (1) (1)	**(3)**
	Total for question 13		**7**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>*14a</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>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
<tr><td>3–2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><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

When temperature is higher, greater energy to electrons (in thermistor)
When temperature is higher, more conduction/free electrons
When temperature is higher, lower resistance in thermistor
Decreased p.d. across thermistor / YZ
Or current in circuit/thermistor increases
Increased p.d. across fixed resistor Or increased p.d. across XY
So for the air conditioning application, secondary circuit should be across XY

(Allow converse statements for IC 1,2, 3 and 4)
(Do not allow contradicting statements for IC4 e.g. lower V so lower I)</td><td>(6)</td></tr>
</table>

14b	Ratio of p.d.s to resistances See either 775 Ω **or** 263 Ω for light dependent resistor Difference = (−) 512 Ω **Or** Use of $R = V/I$ to calculate current See either 775 Ω **or** 263 Ω for light dependent resistor Difference = (−) 512 Ω **<u>Example of calculation</u>** $\frac{7.29\text{ V}}{4.71\text{ V}} = \frac{1200\ \Omega}{R}$ so $R = 775\ \Omega$ $\frac{9.84\text{ V}}{2.16\text{ V}} = \frac{1200\ \Omega}{R}$ so $R = 263\ \Omega$ Difference in resistance = 263 Ω - 775 Ω = (−) 512 Ω	(1) (1) (1) (1) (1) (1)	**(3)**
	Total for question 14		**9**

Question Number	Answer	Mark
15a	<u>Diameter</u> of wire with a micrometer **or** digital calliper (1) <u>Length</u> of wire using a metre rule (1) Potential difference (in parallel with the wire) with a voltmeter **and** current (in series with the wire) with an ammeter **Or** resistance, using an ohmmeter (in parallel with the wire) (1)	**(3)**
15b	Use of πr^2 or $\pi d^2/4$ (1) Suitable axes (1) Corresponding gradient to give resistivity (MP3 dependent on MP2) (1) Some examples of appropriate axes (see table below)	**(3)**
	Total for question 15	**6**

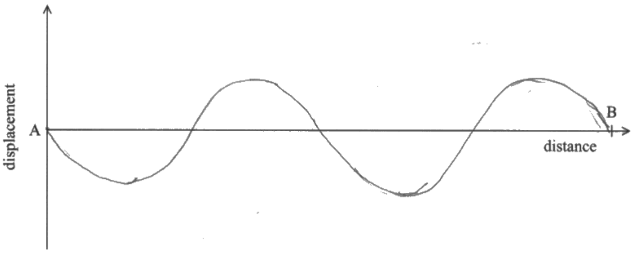
Some examples of appropriate axes

y-axis	x-axis	gradient
R	l	ρ / A
R	l/A	ρ
RA	l	ρ
l	R	A / ρ
l	RA	$1 / \rho$
l/A	R	$1 / \rho$
V	Il	ρ / A

Question Number	Answer	Mark
16a	(Two) waves travelling in opposite directions **Or** Wave reflected back on itself (1) Superposition / interference occurs (1)	**(2)**
16bi	Units of u are ms^{-1} and units of d are m (1) Units of f are s^{-1} (1)	**(2)**
16bii	Use of $v = \sqrt{(T/\mu)}$ (1) Recognises that $\lambda = 2L/3$ **Or** states that $\lambda = 0.22$ m (1) Uses their <u>calculated</u> v and their λ in $v = f\lambda$ to establish f (1) Use of $f = Ku/d$ with their f to establish u (1) $u = 1.1\ ms^{-1}$ (1) **<u>Example of calculation</u>** $v = \sqrt{(T/\mu)} = \sqrt{(63N / 0.58 \times 10^{-3}\ kgm^{-1})} = 330\ ms^{-1}$ $\lambda = 2L/3 = (2 \times 0.33 / 3) = 0.22$ m $f = v/\lambda = 330\ ms^{-1} / 0.22\ m = 1500$ Hz $u = fd/K = [1500\ Hz \times (0.15 \times 10^{-3}\ m)] / 0.2 = 1.125\ ms^{-1}$	**(5)**
	Total for question 16	**9**

Question Number	Answer	Mark
17a	(Pulse reflects at) a boundary between different materials/media/densities (1) (allow "between steel and air" for "between different materials") (allow "speed of ultrasound in air is different to that of steel")	**(1)**
17b	**Method 1** (Calculating distance to crack) Reads time difference of 24.5 - 25 μs from graph (1) Use of speed = distance/time to calculate distance (1) Uses half time or half distance in calculation (1) Depth = 7.1 - 7.3 cm < 15cm, so reflection is from a crack **Or** Depth = 7.1 - 7.3 cm < 15cm, so cannot be from bottom of rail (1) **OR Method 2** (Calculating time to bottom of rail and back) Use of speed = distance/time to calculate time (1) Uses 30cm in calculation (1) Reads time difference of 24.5 - 25 μs from graph (1) Time = 52μs > 24.5 – 25 μs , so reflection is from a crack **Or** Time = 52μs > 24.5 – 25 μs , so cannot be from the bottom of rail (1) **<u>Example of calculation</u>** Time between transmitting and receiving = 24.75μs So time taken to get to point of reflection = 12.375μs Distance = speed × time = 5800 m s^{-1} × (12.375 × 10^{-6}) = 0.072 m.	**(4)**
17c	Most/all of the ultrasound is reflected by the first crack **Or** Pulse does not reach second crack **Or** None of the pulse is transmitted after the crack **Or** Ultrasound signal from deeper cracks is too weak to be detected (1)	**(1)**
17d	The idea that there is a time delay before reflected/received signals return (1) The idea that the train will no longer be in the same position if it is moving too fast. **Or** the idea that the train will be in the same/similar position of it is moving slowly (1)	**(2)**
	Total for question 17	**8**

Question Number	Answer	Mark
18a	Vibrations/oscillations in one plane (1) which includes the direction of wave travel (1) **Or** Vibrations/oscillations in one direction (1) perpendicular to the direction of wave travel (1)	**(2)**
18b	The refracted ray lacks the planes of oscillation in the reflected light. **Or** the refracted ray has a plane of polarisation perpendicular to the plane of polarisation of the reflected light (1) So, the refracted ray must also be partially plane polarised (1) (MP2 conditional on awarding MP1)	**(2)**
18ci	See $n_a\sin\theta_a = n_g\sin\theta_g$ **Or** $n_a\sin\theta_B = n_g\sin r$ (1) $n_a\sin(\theta_B) = n_g\sin(90 - \theta_B)$ **Or** $n_a\sin(\theta_B) = n_g\cos(\theta_B)$ **Or** $\sin r = \cos\theta_B$ (1) $\sin(\theta_B)$ divided by $\cos(\theta_B)$ to give $\tan(\theta_B)$ leading to answer (1)	**(3)**
18cii	Substitution of values into_tan(θ_B) = $\frac{n_g}{n_a}$ (1) $\theta_B = 56°$ (1) **<u>Example of calculation</u>** $\tan(\theta_B) = \frac{n_g}{n_a}$ $\theta_B = \tan^{-1}(1.50 / 1.00) = 56°$	**(2)**
18ciii	Refractive index (of glass) is greater for violet **Or** $\frac{n_g}{n_a}$ is greater for violet **Or** $\tan\theta_B$ / $\sin\theta_B$ / θ_B is greater for violet (1) Clearly links one of the above to the student being incorrect. (1)	**(2)**
	Total for question 18	**11**

Question Number	Answer	Mark
19ai	Minimum labelled at either rarefaction (1)	**(1)**
19aii	Zero displacement at all compressions and/or all rarefactions. (1) Two complete wave cycles shown. (1)  (Allow graph inverted in relation to the one shown above)	**(2)**
19bi	Describes an initial situation where the two traces are in antiphase / phase (1) Record the position of the microphone (from the metre rule) **Or** Measure the distance from the loudspeaker to the microphone (1) Move microphone (gradually) until the two traces are next in antiphase / phase (1) Record the new position of the microphone and calculate the distance moved by the microphone **Or** Measure the new distance from the loudspeaker to the microphone and calculate the distance moved by the microphone (1) Multiply calculated/measured wavelength by frequency to determine the speed **Or** Describes a suitable graph to determine the speed (1) (MP5 - examples of suitable graphs are λ against $1/f$ or f against $1/\lambda$. Both would give a gradient of v which needs to be stated to achieve the mark)	**(5)**
19bii	Time period read off oscilloscope (from one point to the next in phase point) **Or** number of waves per second read off oscilloscope (1) Time period (for both traces) is the same (1)	**(2)**
19biii	Use of $v = f\lambda$ (1) Calculates λ of 8.5 cm (for 4.0 kHz) **and** 2.3 cm (for 15.0 kHz) (1) Percentage uncertainty greater for 2.3cm than 8.5cm (so student correct) **Or** Percentage uncertainty greater for 15.0kHz than 4.0kHz (so student correct) **Or** Percentage uncertainty is reduced if measurements taken across several wavelengths (so student not necessarily correct) (1) (Do not allow "uncertainty" for "percentage uncertainty") **Example of calculation** $\lambda = v/f = (340\ \text{ms}^{-1}) / (4000\ \text{Hz}) = 0.085\ \text{m}$ $\lambda = v/f = (340\ \text{ms}^{-1}) / (15000\ \text{Hz}) = 0.023\ \text{m}$	**(3)**
	Total for question 19	**13**

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