Mark Scheme (Results)

Summer 2016

Pearson Edexcel GCE
in 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.

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:

<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:

$80\ \text{cm} \times 50\ \text{cm} \times 1.8\ \text{cm} = 7200\ \text{cm}^3$

$7200\ \text{cm}^3 \times 0.70\ \text{g cm}^{-3} = 5040\ \text{g}$

$5040 \times 10^{-3}\ \text{kg} \times 9.81\ \text{N/kg}$

$= 49.4\ \text{N}$

5. Quality of Written Communication

5.1 Indicated by QWC 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 QWC 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	B	**1**
3	C	**1**
4	A	**1**
5	D	**1**
6	C	**1**
7	B	**1**
8	C	**1**
9	B	**1**
10	B	**1**

Question Number	Answer	Mark
11	Use of resistors in parallel formula **(1)** Use of resistors in series formula **(1)** R = 68 Ω **(1)** <u>Example of calculation</u> (1/22 Ω) + (1/620 Ω) = 0.0471 Ω^{-1} Resistance for parallel section = 21.2 Ω 47 Ω + 21.2 Ω = 68.2 Ω	**3**
	Total for question 11	**3**

Question Number	Answer	Mark
***12**	**(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate)** Electrons spread out **Or** electrons form a diffraction/interference pattern **Or** undergo superposition **(1)** Electrons must behave as waves **Or** Electrons have a wavelength (similar to the atomic spacing) **(1)** Because diffraction/interference is wave behaviour **(1)**	**3**
	Total for question 12	**3**

Question Number	Answer		Mark
13	**Either** (Unpolarised) light has oscillations in all planes Vertically polarised light has oscillations in a vertical plane only The vertical plane includes the direction of propagation of the light (dependent mark) **Or** (Unpolarised) light has oscillations in all directions Vertically polarised light has oscillation in a vertical direction only … perpendicular to the direction of propagation (dependent mark)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**3**
	Total for question 13		**3**

Question Number	Answer		Mark
14 (a)	Use of R = V/I (for current) Use of sum of e.m.f. = sum of p.d.s Or use of $\mathcal{E} = V + Ir$ r = 100 000 Ω or 100 kΩ or 1× 10^5 Ω (Accept valid alternative methods based on potential divider) Example of calculation I = 0.018 V / 4700 Ω = 3.8 × 10^{-6} A 0.4 V = 0.018 V + (3.8 × 10^{-6} A × r) r = 100 000 Ω	**(1)** **(1)** **(1)**	**3**
14 (b)	Use of power = radiation flux × area Use of an electrical power equation Use of efficiency equation Efficiency = 12 % (Full ecf for current from (a)) Example of calculation power = 1.5 × 10^{-3} W m^{-2} × 3.9 × 10^{-4} m^2 = 5.85 × 10^{-7} W power = IV = 3.8 × 10^{-6} A × 0.018 V = 6.84 × 10^{-8} W Efficiency = 6.84 × 10^{-8} W / 5.85 × 10^{-7} W = 0.12 OR 12 %	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 14		**7**

Question Number	Answer	Mark
***15 (a)**	**(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate)** Only one photon can transfer energy to a single electron **Or** a photon transfers all of its energy to a single electron **(1)** Photon energy depends on frequency **Or** photon energy = hf **(1)** Therefore photons must have a frequency greater than or equal to the minimum frequency (threshold frequency) in order to provide sufficient energy **Or** photon energy must be greater than work function **(1)** Light with a greater intensity supplies more photons per second **(1)** So more electrons can be emitted per second, causing a greater current **(1)** MP4 and MP5 can both be awarded if 'per second' mentioned at least once.	**5**
15 (b)	Use of $E = hf$ **(1)** Use of energy divided by 1.6×10^{-19} C **(1)** Maximum electron ke = 0.49 (eV) **(1)** <u>Example of calculation</u> Max ke = 6.63×10^{-34} Js × (7.52×10^{14} Hz - 6.34×10^{14} Hz) ÷ 1.6×10^{-19} C = 0.49 eV	**3**
	Total for question 15	**8**

Question Number	Answer	Mark
16 (a)	There is a change in density from water to air **Or** There is a change in light speed from water to air **(1)** This causes a change in direction of light (away from normal travelling from water to air) **(1)** So light appears to come from a different point of origin **(1)**	**3**
16 (b)	Use of refractive index = speed of light in air / speed of light in water **(1)** Speed of light in water = 2.26×10^{8} m s^{-1} **(1)** <u>Example of calculation</u> 1.33 = 3.00×10^{8} m s^{-1} / Speed of light in water Speed of light in water = 2.26×10^{8} m s^{-1}	**2**
16 (c) (i)	Angle in water measured as 27° to 29° **(1)** Use of 1.33 × sin (angle in water) = 1.00 × sin (angle in air) **(1)** Angle in air calculated as 37° to 40° **(1)** <u>Example of calculation</u> 1.33 × sin (28°) = 1.00 × sin (angle in air) Angle in air = 38.6°	**3**
16 (c) (ii)	Ray drawn on diagram refracting away from the normal and extrapolated back **(1)** Label or other explanation that light appears to come from a different position (accept ray directed to an eye or stick in new position) **(1)**	**2**
	Total for question 16	**10**

Question Number	Answer		Mark
17(a)(i)	Superposition/interference between waves travelling in opposite directions (from open end and wave reflected at closed end) At node the waves are in antiphase, so there is destructive interference **Or** At the antinode they are in phase so there is constructive interference At an antinode there is maximum <u>amplitude</u> **Or** At a node there is zero <u>amplitude</u>	**(1)** **(1)** **(1)**	**3**
17(a)(ii)	Show a pattern of alternating nodes and antinodes, labelled or waveform, with node at closed end Show a pattern of alternating nodes and antinodes, labelled or waveform, with antinode at open end frequency consistent with a correct pattern e.g NANA = 1230 Hz or NANANA = 2050 Hz	**(1)** **(1)** **(1)**	**3**
17(b)	Records frequency from the graph (375 Hz, 1150 Hz, 1900 Hz) Determines wavelength for chosen frequency 375 Hz: 4 × tube length (= 81.2 cm) 1150 Hz: 4/3 × tube length (= 27.1 cm) 1900 Hz: 4/5 × tube length (= 16.2 cm) use of $v = f\lambda$ $v = 305 \text{ m s}^{-1}$ <u>Example of calculation</u> wavelength = 4 × tube length = 81.2 cm $v = f\lambda$ = 375 Hz × 0.812 m = 305 m s^{-1}	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 17		**10**

Question Number	Answer	Mark
18(a)(i)	Two relevant precautions with reasons, e.g. Ensure that the thermometer and coil are at the same part of the beaker so that the results are not affected by differences in temperature **(1)** Stir water so that the results are not affected by differences in temperature **(1)** Check the meter for zero error by connecting a lead across its terminals so there is no systematic error in the resistance measurements **(1)** Ensure small current so no heating effect in addition to hot water which would make results inaccurate **(1)** Switch off between readings so no heating effect in addition to hot water which would make results inaccurate **(1)** Read thermometer at eye level to avoid parallax errors **(1)**	**2**
18(a)(ii)	This will ensure that the readings are simultaneous **Or** Higher sampling rate **(1)**	**1**
18(b) (i)	(The straight line) does not pass through the origin **(1)**	**1**
18 (b) (ii)	As temperature increase the (lattice) ion/atom vibrations increase **(1)** (for the same current) electrons will collide more frequently with the vibrating (lattice) ions/atoms **(1)** More energy dissipated by collisions so (for constant I) greater V required **Or** (constant V gives) lower v and, since $I = nAvq$, I will be lower **(1)** Since V increases and $R = V/I$, R will increase with temperature **Or** Since I decreases and $R = V/I$, R will increase with temperature **(1)**	**4**
18(c)	Use of $R = \rho l/A$ **(1)** Use of correct area in $R = \rho l/A$ **(1)** length = 0.66 m **(1)** <u>Example of calculation</u> $l = 12.4\ \Omega \times 5.19 \times 10^{-9}\ \text{m}^2 / 9.71 \times 10^{-8}\ \Omega\ \text{m}$ length = 0.663 m	**3**

18(d)	Use of ratio of resistors = ratio of p.d.s **Or** Use of *I* = *V/R* for fixed resistor and *R* = *V/I* for resistance under investigation **(1)** Resistance of resistor = 14.4 (Ω) **(1)** Temperature (from graph) = 27 °C to 29 °C **(1)** <u>Example of calculation</u> 24 Ω / *R* = 7.5 V / 4.5 V Resistance of resistor = 14.4 Ω Temperature (from graph) = 28 °C	**3**
	Total for question 18	**14**

Question Number	Answer	Mark
19(a)	Use of distance = speed × time **(1)** Correct use of factor 2 **(1)** Distance = 7.7 m **(1)** <u>Example of calculation</u> Distance = 340 m s^{-1} × 0.045 s / 2 = 7.65 m	**3**
19 (b)	<u>Higher frequency:</u> Higher frequency gives a shorter wavelength **(1)** So there is less diffraction (and the reflected intensity is higher) **Or** Allowing greater detail from the returned pulses **(1)** <u>Shorter pulse duration:</u> Shorter pulses have a shorter length **(1)** So they locate the prey more precisely **Or** allow greater detail **Or** allows a shorter return time so overlapping of reflected and emitted pulses is prevented **(1)** <u>Separated by a shorter time interval:</u> Separated by a shorter time (because the prey is closer) so the pulses travel a smaller distance and they return more quickly **(1)** So the reflected pulses don't overlap with the emitted pulses **Or** to allow more frequent monitoring of the prey's position **(1)** (max 1 mark for unqualified 'greater detail')	**6**
19(c)	Doppler effect causes change in wavelength / frequency **Or** States (relative) motion of source (and observer) causes change in wavelength / frequency **(1)** If the frequency is increased (the bat can tell that) the prey is moving towards (it) **(1)** If the frequency is decreased (the bat can tell that) the prey is moving away from (it) **(1)** Accept, in place of MP2 or MP3, the frequency change is proportional to the velocity so the bat can deduce the speed of the prey	**3**
	Total for question 19	**12**

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