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Mark Scheme (Results)
January 2012

GCE Physics (6PH05) Paper 01
Physics from Creation to Collapse

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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 m s^{-2} or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 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:

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

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

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

$= 49.4 \text{ N}$

5. Quality of Written Communication

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

Question Number	Answer	Mark
11	See $g = \frac{GM}{r^2}$ **(1)** Correct substitution into $g = \frac{GM}{r^2}$ **(1)** $r_E/r_m = 3.7$ **(1)** (Correct inverse ratio i.e. $r_m/r_E = 0.27$, scores full marks) <u>Example of calculation</u> $g_E = \frac{GM_E}{r_E^2} \qquad g_m = \frac{GM_m}{r_m^2}$ $\therefore \frac{g_E}{g_m} = \frac{GM_E/r_E^2}{GM_m/r_m^2} = \frac{M_E}{M_m} \times \frac{r_m^2}{r_E^2}$ $\therefore 6 = 81 \times \frac{r_m^2}{r_E^2}$ $\therefore \frac{r_E}{r_m} = \sqrt{\frac{81}{6}} = 3.67 \approx 3.7$	3
	Total for question 11	**3**

Question Number	Answer		Mark
12(a)	Use of $P = 4\pi r^2 \sigma T^4$ Power = 2.3×10^{17} W [Temperature in ^{o}C or incorrect conversion to Kelvin can score 1st mark] <u>Example of calculation</u> $P = 4\pi(6.4 \times 10^{6}\ \text{m})^2 \times 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4} \times (298\ \text{K})^4$ $\therefore P = 2.3 \times 10^{17}\ \text{W}$	**(1)** **(1)**	**2**
12 (b)	Use of $\lambda_{max} T = 2.898 \times 10^{-3}$ $\lambda_{max} = 9.7 \times 10^{-6}$ m [Temperature in ^{o}C or incorrect conversion to Kelvin can score 1st mark] <u>Example of calculation</u> $\lambda_{max} = \dfrac{2.898 \times 10^{-3}\ \text{m K}}{298\ \text{K}} = 9.7 \times 10^{-6}\ \text{m}$	**(1)** **(1)**	**2**
12 (c)	Infra-red (radiation/light/wave) [accept Infrared/IR]		**1**
	Total for question 12		**5**

<table>
<tr><th>Question Number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>13(a)</td><td>Acceleration is:
• (directly) proportional to displacement from equilibrium position
• (always) acting towards the equilibrium position Or idea that acceleration is in the opposite direction to displacement

[accept undisplaced point/fixed point/central point for equilibrium position]

Or

Force is:
• (directly) proportional to displacement from equilibrium position
• (always) acting towards the equilibrium position Or idea that force is a restoring force e.g. “in the opposite direction”

[accept towards undisplaced point/fixed point/central point for equilibrium position]

[An equation with symbols defined correctly is a valid response for both marks.
e.g $a \propto -x$ or $F \propto -x$]</td><td>(1)
(1)

(1)
(1)</td><td>2</td></tr>
<tr><td>13(b)(i)</td><td>Amplitude = 2.3 m [allow ±0.1 m]
Time period = 24 hours [allow ±0.5 hour]

[24 hours = 86 400 s]

<u>Example of calculation</u>
Amplitude = (6.1 m – 1.5 m)/2 = 2.3 m
Period = (48 hr – 0 hr)/2 = 24 hr</td><td>(1)
(1)</td><td>2</td></tr>
<tr><td>13(b)(ii)</td><td>Use of $\omega = \frac{2\pi}{T}$
Use of $v = (-)A\omega \sin \omega t$ [$v_{max} = \omega A$]
v_{max} = 0.60 m hr^{-1}

<u>Example of calculation:</u>
$\omega = \frac{2\pi}{T} = \frac{2\pi \text{ rad}}{24 \text{ hr}} = 0.262 \text{ rad hr}^{-1}$
$v_{max} = 0.262 \text{ rad hr}^{-1} \times 2.3 \text{ m} = 0.602 \text{ m hr}^{-1}$

Or

Attempt to calculate gradient with a max Δt = 12 hours, and max Δx = 6 m
Rate of change of depth in range (0.54 – 0.66) m hr^{-1}
Rate of change of depth in range (0.57 – 0.63) m hr^{-1}

<u>Example of calculation</u>
Rate of change of depth = $\frac{(6.5-1.0)}{(11.0-1.5)} = 0.57$</td><td>(1)
(1)
(1)

(1)
(1)
(1)</td><td>3</td></tr>
<tr><td>13(b)(iii)</td><td>Graph with correct shape [minus sine curve, at least 30 hours]
Same time period as graph given, constant amplitude</td><td>(1)
(1)</td><td>2</td></tr>
<tr><td></td><td>Total for question 13</td><td></td><td>9</td></tr>
</table>

Question Number	Answer	Mark
*14	QWC – Work must be clear and organised in a logical manner using technical wording where appropriate **Max 5** • Reference to resonance **(1)** • The sounding box is forced to vibrate (at the frequency of the tuning fork) **(1)** • Tuning fork and sounding box have similar natural frequencies **(1)** • Energy transferred from the tuning fork to the box **(1)** • The sounding box sets a large amount/mass/volume of air into vibration **(1)** • (Hence) the sound (wave) produced (in the air) has a larger amplitude **(1)** • Sounding box dampens the vibration (of the tuning fork) **(1)** • Larger rate of transfer of energy (to the air) means that the vibration persists for a shorter time **(1)**	5
	Total for question 14	**5**

Question Number	Answer	Mark
15(a)	Use of $\Delta E = mc\Delta\theta$ **(1)** Energy transferred = 2.8 × 10^6 J **(1)** Example of calculation $\Delta\theta$ = (60 – 15) = 45 °C $E = mc\Delta\theta = 15\,\text{kg} \times 4200\,\text{J kg}^{-1}\,\text{K}^{-1} \times 45\,\text{K} = 2.84 \times 10^6\,\text{J}$	**2**
15 (b)(i)	Use of $P = \dfrac{\Delta W}{\Delta t}$ **(1)** Time = 1100 s **(1)** (Allow answers that use ΔW in range 2.5 MJ → 3.4 MJ. t = 1200s if 3MJ used and 1000s to 1360 s for allowed range,) Example of calculation $\Delta t = \dfrac{\Delta W}{P} = \dfrac{2.84 \times 10^6\,\text{J}}{2500\,\text{W}} = 1136\,s \approx 1100\,s$	**2**
15 (b)(ii)	Idea that all energy supplied results in a rise in temperature **(1)** [e.g. only water heated up **Or** no energy transferred to surroundings etc]	**1**
15(c)	Use of $P = IV$ **(1)** Current = 11A **(1)** Example of calculation $I = \dfrac{P}{V} = \dfrac{2500\,\text{W}}{230\,\text{V}} = 10.9\,\text{A}$	**2**
	Total for question 15	**7**

Question Number	Answer		Mark
16(a)	The weight of the moon **Or** the gravitational force of the Earth (on the moon) The (mass of the Earth and) speed/velocity of the moon	**(1)** **(1)**	**2**
16(b)	A centripetal / unbalanced force is needed (because the water is moving in a circular path) **Max 2** At the highest point the (unbalanced) force is weight of water plus reaction from bucket Idea that the minimum force needed (towards the centre of the circle) is the weight of the water Minimum velocity where $\frac{mv_{\min}^2}{r} = mg$ **Or** $v_{\min}^2 = rg$ [Credit may be given for a diagram with appropriate annotations]	**(1)** **(1)** **(1)** **(1)**	**Max 3**
	Total for question 16		**5**

Question Number	Answer		Mark
17(a)	Use of $\omega = \sqrt{\frac{k}{m}}$ and $T = \frac{2\pi}{\omega}$ OR use of $T = 2\pi\sqrt{\frac{m}{k}}$ Time period = 0.43 s [allow any value that rounds to 0.4 s] <u>Example of calculation</u> $\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{120\ \mathrm{N\,m^{-1}}}{0.55\ \mathrm{kg}}} = 14.8\ \mathrm{rad\,s^{-1}}$ $T = \frac{2\pi\ \mathrm{rad}}{14.8\ \mathrm{rad\,s^{-1}}} = 0.425\ \mathrm{s}$	**(1)** **(1)**	**2**
17(b) (i)	Energy of the system is dissipated or energy is removed from the system (by frictional forces) (Hence) the amplitude reduces	**(1)** **(1)**	**2**
17(b) (ii)	Sinusoidal graph with at least 2 cycles Decreasing amplitude Approximately constant time period	**(1)** **(1)** **(1)**	**3**
	Total for question 17		**7**

Question Number	Answer	Mark
18 (a)	A radioactive isotope has an unstable nucleus **(1)** (Which decays and) emits radiation **Or** α/β/γ (radiation) specified **(1)**	**2**
18 (b)	**Max 2** We can't know when an individual nucleus will decay **(1)** We can't know which nucleus will decay next **(1)** (In a given time interval) each nucleus has a fixed probability of decay **Or** (In a given time interval) a fixed fraction of nuclei undergo decay **(1)** [accept atom for nucleus, but there is a one mark penalty for using particle, molecule or isotope]	**2**
18 (c)	Identify half life = 5730 years **(1)** Use of $\lambda = \frac{\ln 2}{t_{1/2}}$ **(1)** Decay constant = 1.21×10^{-4} (yr^{-1}) [3.84×10^{-12} (s^{-1})] **(1)** N/N_0=0.60 **(1)** Use of $N = N_0 e^{-\lambda t}$ **(1)** Age = 4220 yr [1.34×10^{11} s] **(1)** Example of calculation $\lambda = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{5730} = 1.21 \times 10^{-4}\ \text{yr}^{-1}$ $\frac{N}{N_0} = 0.6 = e^{-1.21\times10^{-4}t}$ $\therefore \ln(0.6) = -1.21\times10^{-4}t$ $\therefore t = \frac{\ln(0.6)}{-1.21\times10^{-4}} = 4220\ \text{yr}$	**6**
18(d)	Ratio of C-14 to C-12 (in living material) was greater in the past **(1)** Appreciation that we are not comparing 'like with like' e.g. ratio used is from current matter **(1)** (Hence) the age of Stonehenge has been underestimated **(1)**	**3**
	Total for question 18	**13**

Question Number	Answer	Mark
*19 (a)	QWC – Work must be clear and organised in a logical manner using technical wording where appropriate **Process of fusion: Max 2** In nuclear fusion small nuclei fuse / join together to produce a larger nucleus **(1)** Mass of the fused nucleus < total mass of initial nuclei **(1)** (Energy is released as) $\Delta E = c^2\Delta m$ **Or** B.E./nucleon increases (so energy is released) **(1)** **Conditions: Max 3** A very high temperature **(1)** To overcome the (electrostatic) repulsion between nuclei **(1)** A (very) high pressure/density **(1)** To maintain a high/sufficient collision rate **(1)** **Difficult to replicate: Max 2** (Very high) temperatures lead to confinement problems **(1)** Contact with container causes temperature to fall (and fusion to cease) **(1)** Very strong magnetic fields are required **(1)**	**Max 6**
19 (b)	Idea that ^{56}Fe is the peak of the graph **(1)** If nuclei were to be formed with A > 56, the B.E./nucleon would decrease **(1)** This would require a net input of energy (and so does not occur) **(1)**	**3**
19 (c)(i)	(A star/astronomical) object of known luminosity (due to some characteristic property of the star/object) **(1)**	**1**
19(c)(ii)	Use of $F = \dfrac{L}{4\pi d^2}$ **(1)** Distance = 9.3×10^{24} m **(1)** Example of calculation $d = \sqrt{\dfrac{2.0\times10^{36}\ \text{W}}{4\pi\times10^{-15}\ \text{W m}^{-2}}} = 9.30\times10^{24}\ \text{m}$	**2**
19(c)(iii)	The galaxy is receding / moving away from the Earth **(1)**	**1**
19(c)(iv)	Use of $Z=v/c$ **(1)** Use of $v=Hd$ **(1)** Hubble constant = $2.1 \times 10^{-18}\ \text{s}^{-1}$ **(1)** Example of calculation $v = Zc = 0.064\times3\times10^{8}\ \text{m s}^{-1} = 1.92\times10^{7}\ \text{m s}^{-1}$ $H = \dfrac{v}{d} = \dfrac{1.92\times10^{7}\ \text{m s}^{-1}}{9.30\times10^{24}\ \text{m}} = 2.06\times10^{-18}\ \text{s}^{-1}$	**3**
	Total for question 19	**16**

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