Mark Scheme (Results)

Summer 2013

GCE Physics (6PH05)

Paper 01: Physics-Creation/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.

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. '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:

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

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

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

$= 49.4\text{ N}$

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.

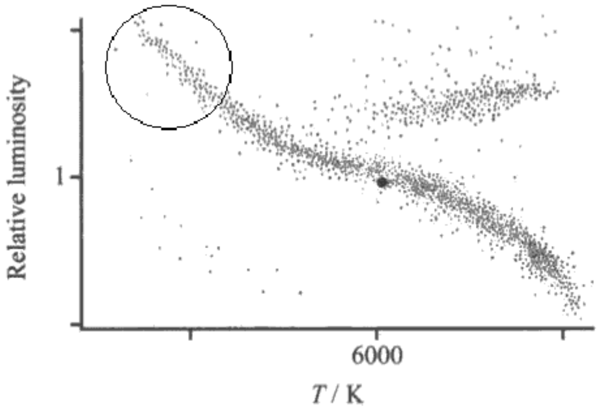
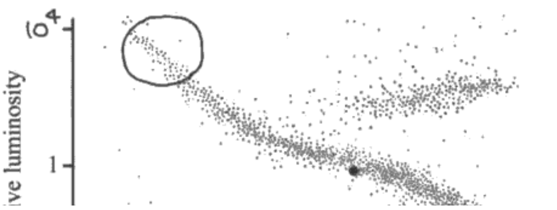
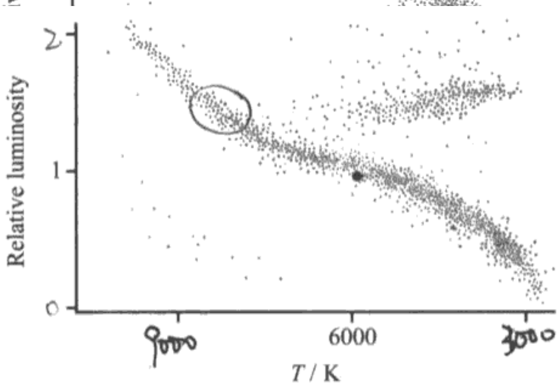
6.5 For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Question Number	Answer	Mark
1	A	**1**
2	C	**1**
3	C	**1**
4	D	**1**
5	C	**1**
6	C	**1**
7	D	**1**
8	D	**1**
9	B	**1**
10	B	**1**

Question Number	Answer		Mark
11	Galaxies are receding **O**r galaxies are moving away (from us and from each other) **T**he greater the distance the greater the velocity The universe is expanding	**(1)** **(1)** **(1)**	**3**
	Total for question 11		**3**

Question Number	Answer		Mark
12(a)	(B2 =) 2.9×10^{-3}/A2 **Or** (B2 =) $2.9 \times 10^{-3}/\lambda_{max}$ **Or** (B2=) $2.9 \times 10^{-3}/6.85 \times 10^{-7}$ [Ignore incorrect powers of 10]	**(1)**	**1**
12(b)	Use of $L = \sigma T^4 A$ $A = 0.21(48) \times 10^{19}$ (m^2) For max 1 Use of $A = 4\pi R^2$ to give $A = 2.1(1)\times 10^{18}$ (m^2) Example of calculation: $A = \dfrac{0.392\times10^{26}\ \text{W m}^{-2}}{5.67\times10^{-8}\ \text{W m}^{-4}\ \text{K}^{-4}\times(4230\ \text{K})^4} = 2.148\times10^{18}\ \text{m}^2$	**(1)** **(1)**	**2**
12(c)	Flux/brightness/intensity measured and distance to star determined (Luminosity calculated using) $L = 4\pi d^2 F$ **Alternative mark scheme:** Temperature and type of star identified [e.g. main sequence]	**(1)** **(1)** **(1)**	

	Hertzsprung-Russell diagram used to find luminosity **(1)**	**2**
	Total for question 12	**5**

Question Number	Answer	Mark
13(a)	Luminosity scale: Log scale [$10^3 \rightarrow 10^6$ (top) and $10^{-3} \rightarrow 10^{-6}$ (bottom)] **(1)** Temperature scale: reverse log/power scale [e.g. 12,000 (left) and 3000 (right)] **(1)**	**2**
13(b)(i)	(Fusion of) hydrogen into helium [accept symbols] **(1)**	**1**
13(b)(ii)	Circle around stars top left of main sequence [included in the area indicated below] **(1)**  **Max 2** They have the highest temperatures **Or** they are the most luminous [accept brightest] **(1)** (Because) they fuse H (into He) at the highest/higher rate **(1)** (Because) they have the largest/larger gravitational forces **(1)** [Max 1 mark if no comparative]  Both scale marks and correct area identified  Neither scale mark and area too low	**3**

	Total for question 13	**6**

Question Number	Answer		Mark
14(a)	See (unbalanced force), $F = \frac{Gm_1m_2}{r^2}$ Apply N2 with $a = v^2/r$ **Or** Equate F with mv^2/r **Or** Equate F with $m\omega^2 r$ Use of $T = 2\pi r/v$ **Or** $T = 2\pi/\omega$ T = 43000 (s) **Or** At height of satellite orbit, use $g = GM/r^2$ Use $g = a = \omega^2 r$ **Or** $g = a = v^2/r$ Use of $T = 2\pi r/v$ **Or** $T = 2\pi/\omega$ T = 43000 (s) [First 3 marks can be obtained from use of $T = 2\pi\sqrt{\frac{r^3}{GM}}$] [If reverse show that to calculate h = 18 900 km, then max 3 marks] <u>Example of calculation:</u> $\frac{GMm}{r^2} = \frac{mv^2}{r}$ $v = \sqrt{\frac{GM}{r}}$ r = (20200 + 6400) km = 2.66 × 10^7 m $v = \sqrt{\frac{6.67\times10^{-11}\ \mathrm{N\,m^2\,kg^{-2}} \times 6.0\times10^{24}\ \mathrm{kg}}{2.66\times10^7\ \mathrm{m}}} = 3.88\times10^3\ \mathrm{m\,s^{-1}}$ $T = \frac{2\pi\times2.66\times10^7\ \mathrm{m}}{3.88\times10^3\ \mathrm{m\,s^{-1}}} = 43100\,\mathrm{s}$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	4
14(b)	Communications satellites must be in the same position in sky at all times **Or** communications satellites must be in a geostationary orbit (So) communications satellites must rotate at the same rate as the Earth **Or** communications satellites must have same angular velocity as the Earth **Or** communications satellites must have same period as the Earth **Or** communications satellites must be in geosynchronous orbits	**(1)** **(1)**	2
14(c)	The radius of the GPS satellite orbit is smaller	**(1)**	

	The orbit of the communications satellite must be in an equatorial plane **(1)** [Converse accepted for both marks. Do not credit references to velocity or period]	**2**
	Total for question 14	**8**

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Question Number	Answer		Mark
15(a)	(When the air is heated) the density (of air in) the balloon decreases So the upthrust is greater than the weight of the balloon (plus occupants)	**(1)** **(1)**	**2**
15(b)	Use of $\rho = \frac{m}{V}$ Use of $\Delta E = mc\Delta\theta$ [$\Delta\theta$ must be a temperature difference] ΔE = 1.3(5) × 10^9 J <u>Example of calculation:</u> $m = \rho V = 1.20\,\text{kg m}^{-3} \times 7.4 \times 10^4\ \text{m}^3 = 8.88 \times 10^4\ \text{kg}$ $\Delta E = mc\Delta\theta = 8.88 \times 10^4\ \text{kg} \times 1010\ \text{J kg}^{-1}\ \text{K}^{-1}(35-20)\text{K} = 1.345 \times 10^9\ \text{J}$	**(1)** **(1)** **(1)**	**3**
15(c)(i)	Use of $pV = NkT$ [temperature in either K or °C] p = 9.24 × 10^4 Pa <u>Example of calculation:</u> $\frac{p_2}{p_1} = \frac{T_2}{T_1}$ $p_2 = (1.01 \times 10^5)\text{Pa} \times \frac{(273-5)\text{K}}{(273+20)\text{K}} = 9.238 \times 10^4\ \text{Pa}$	**(1)** **(1)**	**2**
15(c)(ii)	**Max 2** Hydrogen/gas behaves as an ideal gas Mass of hydrogen/gas in balloon stays constant [Accept amount of hydrogen/gas] **Or** number of molecules/atoms/particles of hydrogen/gas in balloon stays constant Temperature of hydrogen/gas is the same as the temperature of the surroundings	**(1)** **(1)** **(1)**	**2**
15(c)(iii)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) The average/mean kinetic energy of the molecules decreases Molecules travel slower (on average) **Or** rate of collisions with walls is less So rate of change of momentum (during collisions) with walls is less	 **(1)** **(1)** **(1)**	**3**
	Total for question 15		**12**

Question Number	Answer	Mark
16(a)(i)	(A standard candle is) an object of known luminosity **(1)**	**1**
16(a)(ii)	Flux/brightness/intensity of standard candle is measured **(1)** Inverse square law used (to calculate distance to standard candle) **(1)** [Reference to measurement of apparent magnitude of star, m, and distance calculated using $m - M = 5\log(d/10 \text{ pc})$ can score 2 marks]	**2**
16(b)(i)	An increase in the wavelength (of radiation) received from a receding source **(1)** [accept in terms of a decrease in the frequency]	**1**
16(b)(ii)	Use of $z = v/c$ and $v = H_0 d$ $[z = H_0 d/c]$ **(1)** $d = 1.7 \times 10^{25}$ m **(1)** <u>Example of calculation:</u> $v = zc = 0.12 \times 3\times10^{8}\text{ m s}^{-1} = 3.6 \times10^{7}\text{ m s}^{-1}$ $d = v/\text{H} = 3.6 \times10^{7}\text{ m s}^{-1}/2.1 \times 10^{-18}\text{ s}^{-1} = 1.71 \times 10^{25}$ m	**2**
***16(c)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Max 3** Dark matter has mass but does not emit e-m radiation [accept light] **(1)** (Dark matter proposed when) observations of galaxies indicated that they must contain more matter than could be seen. **(1)** The existence of dark matter will increase the (average) density of the universe **(1)** This may make it more likely that the universe is closed [accept will contract **Or** end with a "Big Crunch"] **(1)** **Or** Idea that this may make the ultimate fate of the Universe less certain	**3**
16(d)	**Max 2** The universe started from a small initial point [accept Big Bang] **(1)** Idea that universe has a finite age **(1)** Idea that (observable universe is finite because) we can only see as far as (speed of light) × (age of universe) **Or** light reaching us must have travelled a finite distance since the Big Bang **Or** some parts of the universe are so distant, light has not had time to reach us yet **(1)**	**2**
	Total for question 16	**11**

Question Number	Answer		Mark
17(a)	A radioactive atom has an unstable nucleus which emits α, β, or γ radiation [at least one of α β γ named]	**(1)** **(1)**	**2**
17(b)	$C \rightarrow {}^{11}_{5}B + {}^{0}_{1}e^{+} + \nu_e$ Top line correct Bottom line correct	**(1)** **(1)**	**2**
17(c)	Attempt at mass diference calculation Attempt at conversion from (M)eV to J $\Delta E = 1.4 \times 10^{-13}$ (J) <u>Example of calculation:</u> ΔE= 10 253.6 – 10252.2-0.5 = 0.889 MeV $\Delta E = 0.889 \text{ MeV} \times 1.6 \times 10^{-13} \text{ J MeV}^{-1} = 1.42 \times 10^{-13}$ J	**(1)** **(1)** **(1)**	**3**
17(d)	The idea that the sample will not produce radiation for very long (because carbon-11 has a relatively short half-life) β particles are not very ionising **Or** positrons are not very ionising **Or** boron is safe in small amounts	**(1)** **(1)**	**2**
17(e)	Use of $\lambda t_{1/2} = \ln 2$ ($\lambda = 5.68 \times 10^{-4}$ s^{-1}) Use of $A = A_0 e^{-\lambda t}$ Use $A = 1.58 \times 10^6$ Bq in $A = A_0 e^{-\lambda t}$ $A_0 = 1.2 \times 10^7$ Bq <u>Example of calculation:</u> $\lambda = \frac{0.693}{1220\text{ s}} = 5.68 \times 10^{-4}\text{ s}^{-1}$ $1.58 \times 10^6 \text{ Bq} = A_0 e^{-5.68\times10^{-4}\text{ s}^{-1} \times 60 \times 60\text{ s}}$ $A_0 = 1.22 \times 10^7$ Bq	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 17		**13**

Question Number	Answer		Mark
18(a)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) (Hooke's Law:) for a spring, force is proportional to extension **Or** $F = k\,\Delta x$ An extension of the spring causes a force towards the equilibrium position **Or** (resultant force towards the equilibrium position, so) $ma = -k\,\Delta x$ Condition for shm is restoring force [acceleration] is proportional to displacement (from equilibrium position) [QWC question, so max 2 if equations given with no further explanation]	**(1)** **(1)** **(1)**	**3**
18(b)	Use of $a = -\omega^2 x$ Use of $T = \frac{2\pi}{\omega}$ T = 1.55 (s) [Credit use of F = k Δx and use of $T = 2\pi\sqrt{\frac{m}{k}}$ for first two marking points] <u>Example of calculation:</u> $\omega = \sqrt{\frac{0.49\,\text{m}\,\text{s}^{-2}}{3.0\times10^{-2}\,\text{m}}} = 4.04\ \text{s}^{-1}$ $T = \frac{2\pi}{4.04\ \text{s}^{-1}} = 1.55\ \text{s}$	**(1)** **(1)** **(1)**	**3**
18(c)(i)	Damped / damping [Do not accept critical/heavy damping]	**(1)**	**1**
18(c)(ii)	Forced / driven	**(1)**	**1**
18(c)(iii)	Resonance f = 0.65 Hz [accept s^{-1}] [0.625 Hz if show that value is used, 0.64 Hz if unrounded value used] <u>Example of calculation:</u> f = 1/1.55 s = 0.645 Hz [allow 2nd mark if they use either their value from (b) or 1.6 s]	**(1)** **(1)**	**2**
18(d)	(With a smaller mass baby) the natural frequency of oscillation would increase **Or** The natural frequency of the system would increase		

	Or The periodic time of the system would decrease Smaller mass baby would have to kick at a higher frequency (to force system into resonance) [accept larger mass baby would have to kick at a lower frequency]	**(1)** **(1)**	**2**
	Total for question 18		**12**

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