Mark Scheme (Results)

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Pearson Edexcel
GCE Advanced Subsidiary in 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.

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) <u>Horizontal force of hinge on table top</u>

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. '<u>resonance</u>'
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 $g = 10\ \text{m s}^{-2}$ or $10\ \text{N kg}^{-1}$ instead of $9.81\ \text{m s}^{-2}$ or $9.81\ \text{N kg}^{-1}$ will be penalised by one mark (but not more than once per clip). Accept $9.8\ \text{m s}^{-2}$ or $9.8\ \text{N kg}^{-1}$

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.

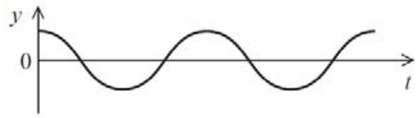
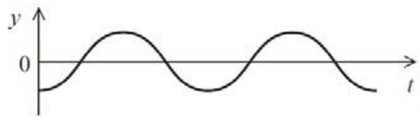
6.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.

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.

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 Standard candles allow astronomers to calculate distances to stars**	**1**
	Incorrect Answers: A – the brightness of a star can be calculated once the distance is known C – the luminosity of a standard candle is a known quantity D – the luminosity **and** surface temperature must be known for the size	
2	**C The penetration of γ-radiation is high and its ionising ability is low**	**1**
	Incorrect Answers: A – it is incorrect to state that γ-radiation has high ionising ability B – it is incorrect to state that γ-radiation has low penetration and high ionising ability D − it is incorrect to state that γ-radiation has low penetration	
3	**B Radioactive decay is spontaneous; we cannot influence when the nucleus decays**	**1**
	Incorrect Answers: A – how the decay occurs depends upon the unstable nuclide C – the amount of energy emitted depends upon the unstable nuclide D – the radiation emitted depends upon the upon the unstable nuclide	
4	**C** $\frac{1}{2}$ **as** $\frac{1}{2}m\langle c^2\rangle = \text{a constant}\ \therefore \frac{\langle c^2\rangle_{\mathrm{Ar}}}{\langle c^2\rangle_{\mathrm{Ne}}} = \frac{m_{\mathrm{Ne}}}{m_{\mathrm{Ar}}} = \frac{1}{2}$	**1**
	Incorrect Answers: A – this is the reciprocal value of the ratio squared B – this is the reciprocal ratio value D – this is the correct ratio squared	
5	**A Peak power would be greater and wavelength at peak power would be smaller**	**1**
	Incorrect Answers: A – correct power change but incorrect wavelength shift B – incorrect power change but correct wavelength shift D – incorrect power change and incorrect wavelength shift	
6	**A Ductile materials can be deformed without becoming brittle and plastic deformation allows high energy absorption**	**1**
	Incorrect Answers: A – a hard material may not be ductile B – the material needs to undergo large deformations D – the material needs to undergo large deformations	
7	**D Distance is calculated with trigonometry, so the baseline distance must be known**	**1**
	Incorrect Answers: A – diurnal prallax is not used for objects outside of the solar system B – the luminosity of the star is unimportant C – this distance is assumed to be infinite	
8	**D Electric fields:** $F_{\mathrm{E}} = \frac{kQq}{r^2}, E = \frac{kQ}{r^2}$. **Gravitational fields:** $F_{\mathrm{G}} = \frac{GMm}{r^2}, g = \frac{GM}{r^2}$	**1**
	Incorrect Answers: (all due to incorrect variables selected from information given) A – field strength is inversely proportional to distance squared B – electric fields can have a zero field strength anywhere C – Gravitational forces can only be attractive	

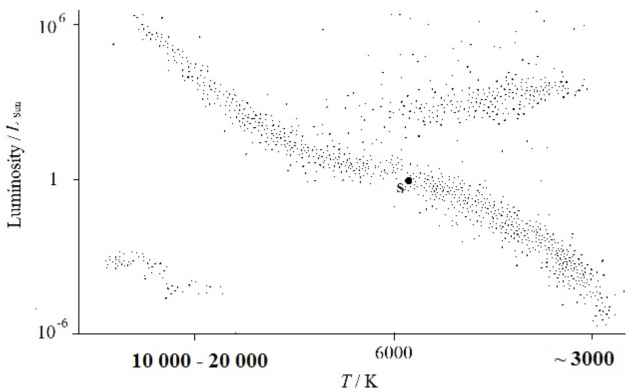
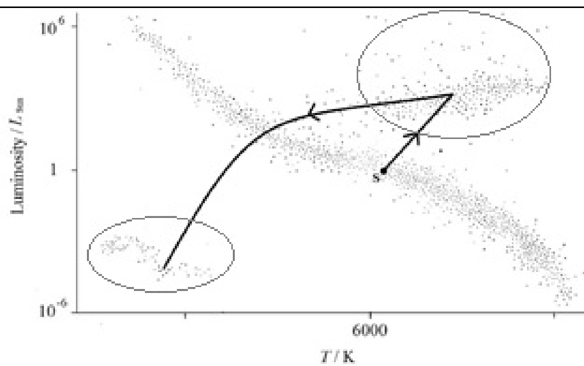
Question Number	Answer	Mark
9	**A The gradient of the displacement time graph shows the velocity** 	**1**
	Incorrect Answers: B – Gradient starts at zero but becomes positive C – gradient starts at a positive value D – gradient starts at a negative value	
10	**B The gradient of the velocity time graph shows the acceleration** 	**1**
	Incorrect Answers: A – y starts at a positive value C – y starts at zero D – y starts at zero	

Question Number	Answer		Mark
11	Use of $\Delta E = mc\Delta\theta$	**(1)**	
	Use of $P = \dfrac{\Delta E}{\Delta t}$	**(1)**	
	P = 11.1 W [accept J s^{-1}]	**(1)**	**3**
	Example of calculation $\Delta E = 1.03\,\text{kg} \times 3930\,\text{J kg}^{-1}\text{K}^{-1} \times (22.5 - 3.5)\,\text{K} = 7.69 \times 10^4\,\text{J}$ $P = \dfrac{7.69 \times 10^4\,\text{J}}{115 \times 60\,\text{s}} = 11.1\,\text{W}$		
	Total for question 11		**3**

Question Number	Answer		Mark
12(a)	Use of $pV = NkT$	**(1)**	
	Conversion of temperature to kelvin	**(1)**	
	$p = 1.14 \times 10^5$ Pa	**(1)**	**3**
	Example of calculation $\dfrac{p_2}{p_1} = \dfrac{T_2}{T_1}$ $\therefore p_2 = \left(\dfrac{273\,\text{K}}{298\,\text{K}}\right) \times 1.24 \times 10^5\,\text{Pa} = 1.136 \times 10^5\,\text{Pa}$		
12(b)	Use of $V\Delta p = \Delta NkT$ to find ΔN **Or** use of pV = NkT to find N and repeated	**(1)**	
	ΔN = 1.4×10^{22} (full ecf from (a))	**(1)**	**2**
	Example of calculation $\Delta N = \dfrac{1.24 \times 10^5\,\text{Pa} \times 0.0051\,\text{m}^3}{1.38 \times 10^{-23}\,\text{m}^2\text{kg}\,\text{s}^{-2}\text{K}^{-1} \times 273\,\text{K}}$ $- \dfrac{1.14 \times 10^5\,\text{Pa} \times 0.0051\,\text{m}^3}{1.38 \times 10^{-23}\,\text{m}^2\text{kg}\,\text{s}^{-2}\text{K}^{-1} \times 273\,\text{K}} = 1.35 \times 10^{22}$		
	Total for question 12		**5**

Question Number	Answer		Mark
13(a)	Two (or more) low mass nuclei come close **Or** two (or more) low mass nuclei collide [Accept “hydrogen” for “low mass”] [Accept “forced together” for “collide”] and then join to form a new nucleus (with larger mass) [Accept “helium” for “new nucleus”]	**(1)** **(1)**	 **2**
***13(b)**	**(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.)** (In the fusion process) there is a decrease in mass, Δm This releases energy ΔE according to the equation $\Delta E = c^2 \Delta m$, where c = speed of light Because large number of fusions are taking place in a star (to release large amount of energy) **Or** because c is so large, even a small mass decrease releases a large amount of energy [If there is a reference to B.E./nucleon rather than a mass decrease, then max 1 for MP1 and MP2]	 **(1)** **(1)** **(1)**	 **3**
13(c)	(Very) high temperature to provide enough energy to overcome (electrostatic) repulsion between nuclei **Or** (very) high temperature to provide enough energy for nuclei to come close enough to fuse [accept reference to strong (nuclear) force]. (Very) high density [accept pressure] so that there is a high collision rate **Or (**very) high density so that a high collision rate is maintained.	 **(1)** **(1)**	 **2**
	Total for question 13		**7**

Question Number	Answer		Mark
*14(a)	**(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.)**		
	Doppler shift is the (fractional) change in wavelength due to relative motion between an observer and a wave source	**(1)**	
	The wavelength of (a line in) the spectrum of light emitted by the galaxy (is measured) and compared with that emitted in the lab	**(1)**	
	$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ is used to calculate the (relative) velocity *v* of the galaxy **Or** $Z = \frac{v}{c}$ is used to calculate the (relative) velocity *v* of the galaxy	**(1)**	
	The wavelength increases if the galaxy is receding **Or t**he wavelength decreases if the galaxy is approaching	**(1)**	**4**
	[Accept reference to "on the Earth" for mp2] [Accept answers in terms of frequency] [Accept "red shift" for "wavelength increases" and "blue shift" for "wavelength deceases"]		
14(b)	There is a shift towards longer wavelengths for all distant galaxies **Or** Light from all (distant) galaxies is red shifted	**(1)**	
	The shift increases as the distance of the galaxy from the earth increases	**(1)**	
	All galaxies are moving away from each other (and the universe is expanding)	**(1)**	**3**
	[Accept "Earth/us" for "each other"]		
	Total for question 14		**7**

Question Number	Answer		Mark
15(a)(i)	Reverse temperature scale Logarithmic/power scale (not obviously linear) 	**(1)** **(1)**	**2**
15(a)(ii)	(This is a white dwarf) Because it is hotter (than the Sun) so it appears to be white And it is dimmer (than the Sun) so (according to $L = \sigma AT^4$) it must have a smaller surface area [accept "smaller radius" in place of "smaller surface area"] [Accept identification star position as being in bottom left area of HR-diagram so a white dwarf star for max 1] [ignore references to the evolutionary processes e.g the contraction of the star after fusion ceases]	**(1)** **(1)**	**2**
15(a)(iii)	Line from S to red giant region [line doesn't have to be straight, but must end at a point above and to the right of S] Line to S to white dwarf region [line doesn't have to be curved as shown, but must end at a point below and to the left of S]	**(1)** **(1)**	**2**

*15(b)	**(QWC Spelling of technical terms must be correct and the answer must be organised in a logical sequence.)** The Sun runs out of hydrogen <u>in its core</u> **(1)** The temperature falls and gravitational forces cause the core to contract releasing energy **(1)** (This causes the temperature to rise and) as helium is fused into heavier elements the Sun expands to a giant star **Or** the star expands and the surface temperature falls forming a red giant star **(1)**	**3**
	Total for question 15	**9**

Question Number	Answer		Mark
16(a)	**Either** (For simple harmonic motion the) acceleration (of the object) 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** (For simple harmonic motion the resultant) force (on the object) 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 $F \propto -x$]	**(1)** **(1)** **(1)** **(1)**	**2**
16(b)(i)	Mean time period calculated using all 3 times [may see T=16.23 s] Use of $f = \frac{1}{T}$ f = 1.54 Hz <u>Example of calculation</u> $T = \frac{(16.3+16.1+16.3)\text{s}}{3\times 25} = 0.649\text{ s}$ $f = \frac{1}{0.649\text{s}} = 1.54\text{Hz}$	**(1)** **(1)** **(1)**	**3**
16(b)(ii)	Use of $\omega = 2\pi f$ Use of $v = \omega A$ v = 0.044 m s^{-1} (full ecf from (b)(i)) <u>Example of calculation</u> $\omega = 2\pi\text{rad}\times 1.54\text{ s}^{-1} = 9.68\text{rad s}^{-1}$ $v = 9.68\text{rad s}^{-1} \times \frac{0.90\times 10^{-2}\text{m}}{2} = 0.0436\text{m s}^{-1}$	**(1)** **(1)** **(1)**	**3**

16(c)(i)	Resonance is when a system forced to oscillate at/near its natural frequency **(1)** Hence producing an effective/maximum transfer of energy **(1)** And an increasing/large amplitude (of oscillation) **(1)**	**3**
16(c)(ii)	Any relevant example, where resonance is essential **(1)** Correct consequence of resonance given for stated example **(1)** e.g. The vibration of air in a musical instrument which occurs at particular frequencies related to the length/size of the resonating cavity, in order that musical sounds can be produced.	**2**
	Total for question 16	**13**

Question Number	Answer		Mark
17(a)(i)	Use of $L = 4\pi r^2 \sigma T^4$ Use of $F = \dfrac{L}{4\pi d^2}$ F = 1.37 kW m^{-2} [accept 1370 kW m^{-2}] <u>Example of calculation</u> $L = 4\pi\left(6.96\times10^{8}\,\text{m}\right)^2 \times 5.67\times10^{-8}\ \text{Wm}^{-2}\text{K}^{-4}\left(5790\,\text{K}\right)^4 = 3.88\times10^{26}\,\text{W}$ $F = \dfrac{3.88\times10^{26}\ \text{W}}{4\pi\left(1.50\times10^{11}\,\text{m}\right)^2} = 1370\,\text{Wm}^{-2}$	**(1)** **(1)** **(1)**	**3**
17(a)(ii)	Use of power = flux × area ecf from (a)(i) Use of % efficiency = (useful power /total power) × 100% P = 1.8 × 10^9 W (allow full ecf from (a)(i)) [with show that value P = 1.85 × 10^9 W] <u>Example of calculation</u> $P = 1370\,\text{Wm}^{-2} \times 6.0\times10^{6}\,\text{m}^2 = 8.22\times10^{9}\,\text{W}$ $P_{\text{out}} = \dfrac{22}{100}\times 8.22\times10^{9}\,\text{W} = 1.81\times10^{9}\,\text{W}$	**(1)** **(1)** **(1)**	**3**

17(b)	Use of $T = \dfrac{2\pi}{\omega}$ Use of $F = \dfrac{GMm}{r^2}$ Use of $F = mr\omega^2$ h = 3.59×10^7 m **Or** Use of $T = \dfrac{2\pi r}{v}$ Use of $F = \dfrac{GMm}{r^2}$ Use of $F = \dfrac{mv^2}{r}$ h = 3.59×10^7 m <u>Example of calculation</u> $\omega = \dfrac{2\pi\,\text{rad}}{24 \times 3600\ \text{s}} = 7.27 \times 10^{-5}\ \text{rad}\,\text{s}^{-1}$ $mr\omega^2 = \dfrac{GMm}{r^2} \quad \therefore\ \omega^2 = \dfrac{GM}{r^3}$ $r = \sqrt[3]{\dfrac{6.67 \times 10^{-11}\ \text{Nm}^2\text{kg}^{-2} \times 5.98 \times 10^{24}\ \text{kg}}{\left(7.27 \times 10^{-5}\ \text{rad}\,\text{s}^{-1}\right)^2}} = 4.226 \times 10^7\ \text{m}$ $h = 4.226 \times 10^7$ m – 6.36×10^6 m = 3.59×10^7 m	(1) (1) (1) (1) (1) (1) (1) (1)	4
17(c)	Space based solar panels are above the atmosphere The rate of solar energy arriving at the Earth's surface is reduced due to atmospheric absorption [accept references to the solar constant at the surface of the Earth being less than 1.4 kW m^{-2} due to atmospheric absorption]	(1) (1)	2
	Total for question 17		**12**

Question Number	Answer		Mark
18(a)	$$Cs \rightarrow {}^{137}_{56}Ba + {}^{0}_{-1}\beta^{-}$$ Top line correct Bottom line correct	(1) (1)	**2**
18(b)	Mass difference calculation Conversion to J $\Delta E = 1.9 \times 10^{-13}$ (J) <u>Example of calculation</u> Δm = [127 528.953 −127 527.267 − 0.511]MeV/c^2 = 1.175 MeV/c^2 ΔE = 1.175 MeV $\Delta E = 1.175 \times 10^6 \times 1.6 \times 10^{-19}$ J eV^{-1} = 1.88×10^{-13} J	(1) (1) (1)	**3**
18(c)	**Max 2 marks from**: (Long) tongs/tweezers should be used to move the source The source should not be pointed at people When not being used the sample should be stored in a lead lined box **Or** the sample should be stored in a thick aluminium box	(1) (1) (1)	**2**
18(d)(i)	Use of $\lambda t_{1/2} = \ln 2$ Conversion of time into seconds Use of $\dfrac{\Delta N}{\Delta t} = (-)\lambda N$ $\dfrac{\Delta N}{\Delta t} = (-)1.62 \times 10^6\,\mathrm{Bq}$ <u>Example of calculation</u> $\lambda = \dfrac{\log_e 2}{30.2 \times 3.15 \times 10^7\,\mathrm{s}} = 7.28 \times 10^{-10}\,\mathrm{s}^{-1}$ $\dfrac{\Delta N}{\Delta t} = (-)\,7.28 \times 10^{-10}\,\mathrm{s}^{-1} \times 2.22 \times 10^{15} = 1.62 \times 10^6\,\mathrm{s}^{-1}$	(1) (1) (1) (1)	**4**
18(d)(ii)	Use of $A = A_0 e^{-\lambda t}$ t = 1230 yr This is many [about 15] times longer than a human lifetime, and so the student's claim is incorrect. <u>Example of calculation</u> $2.0 \times 10^3\,\mathrm{Bq} = 3.2 \times 10^{18}\,\mathrm{e}^{-7.28 \times 10^{-10}\,t}$ $\therefore t = \dfrac{\ln\left(\dfrac{2.0 \times 10^3\,\mathrm{Bq}}{3.2 \times 10^{15}\,\mathrm{Bq}}\right)}{7.28 \times 10^{-10}\,\mathrm{s}^{-1}} = 3.86 \times 10^{10}\,\mathrm{s}$ $t = 3.86 \times 10^{10}$ s / 3.15×10^7 yr^{-1} = 1225 yr	(1) (1) (1)	**3**
	Total for question 18		**14**

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