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Examiners' Report
June 2010

GCE Physics 6PH05

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Introduction

This is the first time that Module 5 of the new specification has been examined. The paper gave candidates the opportunity to demonstrate their understanding of a wide range of topics from this unit. All of the questions elicited responses across the range of marks, but the marks for Q17(c) and Q18(d) tended to be clustered at the lower end of the scale.

Calculation and 'show that' questions gave candidates an opportunity to demonstrate their problem solving skills to good effect. In general responses to such questions were well organised, calculations were accurate, and answers were given to an appropriate numbers of significant figures. There were few unit errors but there were examples of power of ten errors in questions such as Q14(b) where the final answer was required to be in MeV, but candidates quoted an answer that was a million times too large. The most common way to lose marks in a calculation question seemed to be by failing to square, square root or raise quantities to a power four as required in Q15(a) and Q17(a).

Candidates should be encouraged to think about how they set their work out, so that if mistakes are made, their working can be clearly seen so that credit can be given for correct physics. Re-arrangement of equations was sometimes poorly attempted leading to marks being lost. Candidates should be encouraged to substitute numerical values into an equation before attempting a re-arrangement, as this may demonstrate a correct use of the equation even if the final answer is incorrect due to poor algebra. If no working is shown and the final answer is incorrect, then the answer will not score any marks.

It was pleasing to see that candidates were generally able to access the correct data and equations from the list provided. However, it was disturbing to see answers to Q11(b) in which the Boltzmann constant was used in place of the force constant of the spring.

Answers to questions requiring either description or explanation tended to be less clearly organised than answers to calculation questions. Although there were examples of some very good prose answers where candidates used high levels of physical terminology in well-sequenced and logically made answers, it was disappointing to see that arguments were often poorly set out with sloppy use of physical terminology. This was particularly apparent in answers to Q14(c) and Q15(b), which tested items from the specification in a relatively standard way, and which should have been straightforward for well prepared candidates.

It is clear than too many candidates begin to answer the question (and hence fill up the answer space on the paper) before they have fully digested what the question is asking of them. Candidates should be encouraged to pause and think before writing an answer and also to re read what they have written. Descriptive questions often require the answer to be sketched out before the candidate attempts to write in the answer space. In this way candidates may ensure that all relevant points are included in their answer in a logical sequence. The use of bullet points should be encouraged.

The space allowed for responses was usually sufficient. However, candidates need to remember that the space provided does not have to be filled. If they either need more space or want to replace an answer with a different one, they should indicate clearly where that response is to be found.

Question 11(a)

This was straightforward, and most answers gained full marks. Occasionally, the negative sign was omitted from Hooke’s Law, but appeared later in the proof without explanation. A small minority attempted to answer the question using the general equations for SHM and a great deal of algebra.

The question requires Hooke's Law to be used in conjunction with Newton's Second Law.

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Examiner Comments

The candidate has used correct shm equations, but they have done little more than apply some algebra to these equations.

(a) Show that the acceleration of the mouse, a, is given by $a = -\left(\frac{k}{m}\right)x$, where k is the stiffness of the spring. **(2)**

$a = -A\omega^2\cos(\omega t)$

$= -x\omega^2$

$\therefore a = -\frac{k}{m}x$

$A\cos(\omega t) = x$

$T = 2\pi\sqrt{\frac{m}{k}}$

$\frac{T}{2\pi} = \sqrt{\frac{m}{k}}$ $\quad \frac{2\pi}{T} = \sqrt{\frac{k}{m}}$

$\omega = \sqrt{\frac{k}{m}}$

$\omega^2 = \frac{k}{m}$

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Examiner Tip

In a non-numerical question, "show that" requires the expression supplied to be derived from first principles.

Question 11(b)

This question was answered well, with candidates confidently using F = k x, the mass spring oscillator equation and f = 1/T. Some even combined the last two points into one equation. Some found it confusing that they were converting from vertical to horizontal motion, and so they were unable to calculate a value for k. This then led to an attempt at an algebraic expression, sometimes ending up with a correct answer, but in terms of k rather than a numerical value.

Question 12(a)

This question produced mostly good answers, although there was a lack of precision about the distance the beta particles might travel, and about the amount of ionisation they produce. Some candidates were only able to give answers that compared the beta particles with alpha particles. Since alpha radiation is not mentioned in the question, this was an example of answering a question that hadn't been asked. A few candidates were unaware that ionising radiation can penetrate the body, instead of looking for biological explanations (such as sweat) for why radiation could be detected outside of the body.

12 Radioisotopes are often used for medical applications. ^{131}I is a β^--emitter, and can be used to treat an overactive thyroid gland. When a small dose of ^{131}I is swallowed, it is absorbed into the bloodstream. It is then concentrated in the thyroid gland, where it begins destroying the gland's cells.

(a) Patients are advised that radiation detection devices used at airports may detect increased radiation levels up to 3 months after the treatment. Explain how it is possible for the activity of the ^{131}I to be detected outside the body.

(2)

Because, unlike alpha particles, Beta particles can pass through skin unaffected

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Examiner Comments

The answer makes a comparison between alpha and beta radiation.

Question 12(b)(i)

The nature of half life was understood by most of the candidates, but many of them did not read the question and so quoted the fraction of ^{131}I left, rather than the fraction that had decayed.

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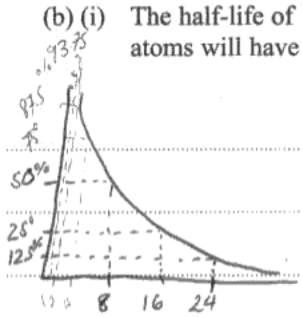
Examiner Comments

This answer clearly demonstrates an understanding of the use of half life, and gives the correct answer. Either 87.5% Or 7/8th would have been acceptable for the final answer mark.

(b) (i) The half-life of ^{131}I is 8 days. What fraction of the original number of iodine atoms will have decayed after a period of 24 days?

(2)



12.5% remaining after 24days (1/8th)

so 87.5% decayed so 7/8 has decayed.

Fraction = 7/8

Question 12(b)(ii)

In the second part most used the right equation and dealt with the exponential functions, but a common mistake was to interchange the mass of isotope at the start and finish of the day period specified. Some weaker candidates were perhaps confused by the question before, assuming that they had to do it by a fraction method rather than using the exponential decay equation. Some of these got close to the correct answer by just trying to work out what fraction would decay in what time.

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Examiner Comments

This answer demonstrates that the candidate does not understand the way in which activity changes over time.

(ii) Doctors wish to prescribe a sample of ^{131}I of activity 1.5 MBq. The sample is prepared exactly 24 hours before it is due to be swallowed by the patient. Calculate the activity that the sample should have when it is prepared.

(3)

1.5 MBq = 1.5×10^6 Bq   24 hrs = $\frac{1}{8}$ half life

$\frac{1}{8}$ half life => $\frac{1}{16}$ iodine atoms decayed.

=> $\frac{15}{16}$ remain

1.5 MBq × $\frac{15}{16}$ = 1.4 MBq

Activity = 1.4 MBq

(Total for Question 12 = 7 marks)

Question 13(a)

This question was generally well done. A large proportion knew of parallax, but only a small proportion were able to say that the distant stars appeared fixed. A few discussed the wobble of stars because of rotating planets.

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Examiner Comments

This answer is brief, but manages to hit all three marking point.

13 When nearby stars are observed over a period of a year, their positions are seen to move in tiny ellipses relative to the background of more distant stars.

(a) Explain why relative movement of these nearby stars is observed.

(3)

This is because the earth is orbiting around the sun, so relative to the "fixed" background stars, the nearby stars appear to move due to trigonametric parallax.

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Examiner Tip

Candidates don't have to fill up the answer space with words to score full marks.

Question 13(b)

This was a generally well answered question. Most candidates drew the symmetrical diagram, which wasn't considered to be a problem. However, the diagrams seen were of very variable quality, with the most common mistakes being:

- only one position of the earth orbiting the sun,
- no angles marked,
- the 'near' star marked as a 'far off star'.

Examples were seen of diagrams showing measurements being made from first one side and then the other of the Earth, and some diagrams indicated measurements being made from the Sun. Most candidates knew that trigonometry together with a knowledge of the radius of the Earth's orbit would be needed to find the distance.

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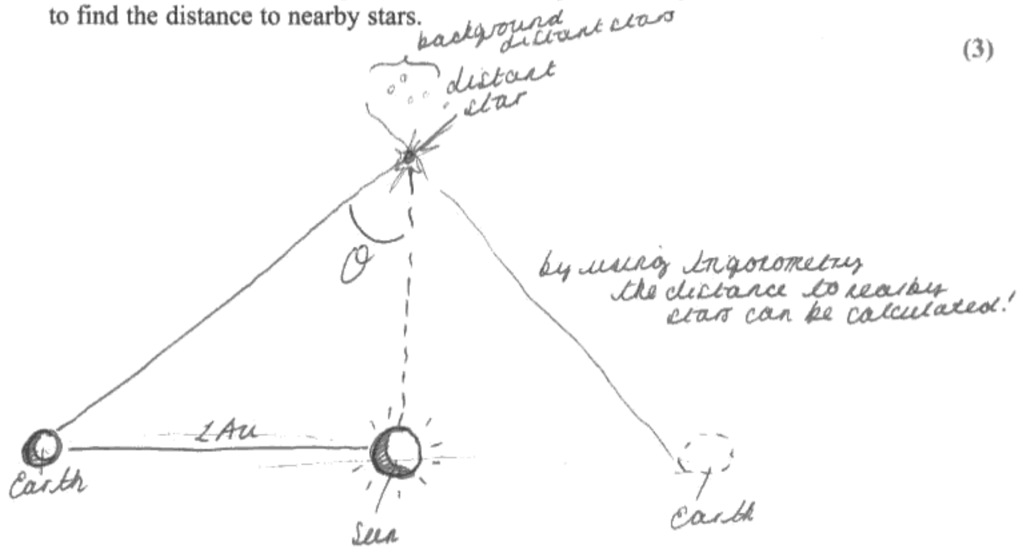
Examiner Comments

Although, this diagram is not the same as the one in the mark scheme, there is sufficient detail included (together with the annotation) for all 3 marks to be awarded.

(b) By means of a labelled diagram, outline the steps necessary for this effect to be used to find the distance to nearby stars.

(3)



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Examiner Tip

Label and annotate diagrams for maximum clarity. Even though, there may be no lines provided, a description can still be included.

Question 13(c)

Most candidates were familiar with standard candles, and there were appropriate references to Cepheid variable stars and supernovae. However, too many answers were seen that referred to red shift, and some answers suggested that a radar pulse can be sent to the star. Many answers discussed intensities and the inverse square law without indicating how luminosities would be known. A small number of responses , referred to the 'candle light' method, which either indicates a superficial knowledge of this part of the specification or a misunderstanding of some of the technical terminology.

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Examiner Comments

This is more than enough detail for the mark to be awarded.

(c) The effect is too small for the distances to more distant stars to be determined.
Outline a method which can be used for more distant stars.

(1)

Standard candles can be used (these are objects of known luminosity). The radiation flux from the star is measured on Earth and the formula $F = \frac{L}{4\pi d^2}$ is used to calculate the distance to the star.

(Total for Question 13 = 7 marks)

Question 14(a)

Most candidates knew that the plastic case, the human skin, or a few cm of air would stop the alpha particles and therefore they would not be a danger to humans. The penetration of air was not always quantitatively described and some candidates thought the alpha particles themselves got ionised.

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Examiner Comments

Although the statement is true, it is lacking in detail and therefore insufficient for the mark to be awarded. The candidate needs to quantify how short the range is by referring to a definite thickness of a material relevant to the situation being described.

14 Ionisation smoke detectors contain a small amount of the radioactive isotope americium. ^{241}Am is an α-emitter. It has a half-life of 432 years, and the activity from the source in a new smoke detector is about 3.5×10^4 Bq.

(a) Explain why the radiation produced by a smoke detector does not pose a health hazard.

(1)

Aalpha particles have short range in air.

Question 14(b)(i)

The equation was completed correctly by the vast majority of the candidates.

(b) (i) Complete the nuclear equation for the decay of americium. **(2)**

$$^{241}_{93}\text{Am} \rightarrow \, ^{240}_{93}\text{Np} + \, ^{1}_{0}\alpha$$

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Examiner Comments

Although nucleon and proton numbers match up before and after the decay, the candidate should have known the correct configuration for an alpha particle.

Question 14(b)(ii)

A large number of answers were seen that gained full marks. Common errors among those who obtained less than full marks included

- using just the mass of the alpha particle to calculate the mass defect
- neglecting to convert from u to kg
- giving the formula E = mc^2 but using E = mc
- attempting to use E = ½mv^2
- an incorrect conversion from J to eV, or eV to MeV.

(ii) Using data from the table, calculate the energy, in MeV, of α-particles released when a nucleus of americium-241 undergoes alpha decay.

(3)

Nuclide	Mass/u
Am	241.056 822
Np	237.048 166
α-particle	4.002 603

241.056822 u → 237.048166 u + 4.002603

241.056822u → 241.050769 u

∴ energy = 241.056822u − 241.050769u

= 6.053×10^{-3}

Energy = 6.053×10^{-3} MeV

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Examiner Comments

The mass deficit has been worked out correctly, but there has been no attempt to convert this mass loss into an energy.

Question 14(c)

Mostly well answered. The most common incorrect answer was to say the half life was 432 years with no reference to a life span.

(c) An ionisation smoke detector is sold with the guarantee that it "lasts a lifetime". Comment on the appropriateness of this guarantee, based on its use of americium-241.

(1)

It would last a lifetime as the half-life is very high at 432 years.

(Total for Question 14 = 7 marks)

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Examiner Comments

Although there is a reference to the half life of the sample, the candidate just re-states that it will "last a lifetime" without attempting to quantify a lifetime in any way.

Question 15(a)(i)

It was unusual to get this wrong, though some candidates used Wien's constant with too few significant figures, and there were some examples of 273 being added to the answer.

Question 15(a)(ii-iii)

The vast majority of candidates realised which equations they use and obtained the correct answers. Of those who made errors in carrying out the calculations, the most common mistake was to fail to raise the temperature to the fourth power in the second equation.

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Examiner Comments

This candidate uses the "show that" values for both L and T to obtain full marks for the question.

(ii) The radiation received from the Sun at the top of the atmosphere is $1.37\ kW\ m^{-2}$. Show the Sun's luminosity is about 4×10^{26} W.

Distance from the Sun to the Earth = 1.49×10^{11} m

(2)

$F = \frac{L}{4\pi d^2}$

$(1.37 \times 1000) = \frac{L}{4\pi (1.49 \times 10^{11})^2}$

$\therefore L = 3.8 \times 10^{26}$ W $\approx 4 \times 10^{26}$ W

(iii) Hence calculate the radius of the Sun.

(2)

$L = 4\pi r^2 \sigma T^4$

$4 \times 10^{26} = 4\pi r^2 (5.67 \times 10^{-8})(6000)^4$

$\therefore r^2 = 4.3 \times 10^{17}$

Radius = 6.58×10^{8} m

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Examiner Tip

If the candidate is unable to calculate the value quoted in a "show that" question, use the "show that" value in the next part of the question.

(ii) The radiation received from the Sun at the top of the atmosphere is 1.37 kW m^{-2}. Show the Sun's luminosity is about 4×10^{26} W.

Distance from the Sun to the Earth = 1.49×10^{11} m

(2)

$I = \frac{L}{4\pi D^2} \Rightarrow L = I\,4\pi D^2$

$= 1.37 \times 10^{+3} \times 4 \times \pi \times (1.49 \times 10^{11})^2$

$= 3.822 \times 10^{26}$ W

$\simeq 4 \times 10^{26}$ W

(iii) Hence calculate the radius of the Sun.

(2)

$L = \sigma A T^4$

$\Rightarrow A = \frac{L}{\sigma T^4} \Rightarrow 4\pi r^2 = \frac{L}{\sigma T^4} \Rightarrow r = \sqrt{\frac{L}{4\pi\sigma T^4}}$

$\Rightarrow r = \sqrt{\frac{3.822 \times 10^{26}}{4\pi \times 5.67 \times 10^{-8} \times 5573}} = 3.102 \times 10^{14}$ m

Radius = 3.10×10^{14} m

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Examiner Comments

Although the candidate has quoted the expression for L correctly in part (iii), they have omitted to raise T to the fourth power and so they do not score any marks in this part of the question.

Question 15(b)

Most candidates recognised that high temperature is needed, but of these, some did not appreciate the need for a high density/pressure. A rather worrying number of responses referred to atoms or molecules, often stating that the particles need high KE to fuse. It was rare for such answers to go on to explain why high KE is necessary. Few answers commented on why the nuclei needed to get very close to fuse, and most candidates did not realise that the rate of collision is a key factor, not just 'having collisions'. Not all of those who referred to repulsion between nuclei said it was electrostatic in origin. Some very weak responses were more in terms of describing fusion rather than concentrating on the conditions necessary for it to happen

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Examiner Comments

The candidate has described the process that produced the conditions for fusion, rather than the conditions.

(b) The huge power output of the Sun is due to nuclear fusion reactions taking place within its core. State and explain the conditions necessary for fusion to occur.

(3)

For fusion to occur, the core must be very hot. The heat is gained due to the contraction of the core, this causes pressure which causes a rise into temperature until the temperature is greater enough for fussion to begin.

(Total for Question 15 = 9 marks)

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Examiner Tip

Encourage candidates to look out for the keywords in the question, and to make sure that their answer addresses the required points.

Question 16(a)

The assumptions were usually identified correctly, although some candidates thought that they had to identify assumptions of the kinetic theory of gases. This may have been due to candidates skim reading and anticipating the question incorrectly.

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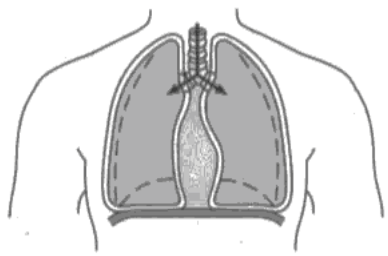
Examiner Comments

The candidate is listing assumptions of the kinetic theory, rather than assumptions necessary to calculate the new pressure.

16 When your diaphragm contracts, the pressure in the chest cavity is lowered below atmospheric pressure and air is forced into your lungs.



(a) The diaphragm contracts and the lung capacity increases by 20%. State **two** assumptions you would need to make to calculate the new pressure in the lungs if the initial pressure is known.

(2)

① The air molecules ~~these~~ themselves are of zero volume.

② There are no forces between the air molecules except during collisions.

Question 16(b)(i-ii)

Candidates were familiar with the density equation and this question was well answered. Where candidates did not obtain the correct answer this was either because they had forgot to multiply by the density or had failed to take into account the number of breaths.

Occasionally candidates added 273 to the temperature difference, but this was not common. A more common error was a unit error. Weaker candidates managed to get a correct answer then proceeded to try to do something odd with a time from part (i) to get a rate.

Question 17(a)(i-ii)

In part (i) most candidates managed to find the time period and either v or ω, but they were not always clear about what to do next.

Nevertheless, a good proportion calculated the acceleration correctly. Marks were sometimes lost due to trying to work out a complete equation in algebra rather than working out individual steps.

In part (ii), the majority of candidates knew the method and carried it through to obtain the correct answer. However, some used 9.81 for g. Equating centripetal force to gravitational force was a common alternative, with some cancelling the mass of HST and substituting their acceleration for v^2/r before correctly calculating the answer.

Question 17(b)

Many candidates knew that the light would have a longer wavelength, but their means of expressing this often lost marks as they did not specifically say that the wavelength would be longer. By saying that the wavelength moves to the red end of the spectrum they did not make it clear where it is moving from.

Most candidates did succeed in stating an inference, the most common being that the universe is expanding. Those who chose other routes sometimes referred to stars, or even planets, when they meant galaxies, hence ideas that the solar system, or even the Earth was expanding were seen in answers to this part of the question.

Question 17(c)(i)

Many candidates had not appreciated what was required here and gave superficial answers, often simply writing the lyrics down again as their answer, rather than considering the link to the physics they had studied. Many termed the edge as a physical edge of the universe and not the limit to the observable universe. In better answers candidates explained the concept of a light year and some of these went on to explain that the age of the universe must be equal to the time that light has been travelling towards us. Quite a few candidates had the misconception that the universe is expanding at the speed of light.

Question 17(c)(ii)

This was generally well answered and most candidates were able to use the reciprocal relationship between the Hubble constant and the age of the Universe. However, a reasonable proportion of candidates omitted to give any units for the Hubble constant, perhaps because they thought that a constant would have no units simply because it was a constant!

Question 17(c)(iii)

Few candidates were able to gain full marks for this question as they seemed distracted from the task or simply unable to formulate a valid argument. Some candidates were able to see the link with data/evidence and 'just a guess', but in the main there was little engagement with "a consideration of scientific findings in a wider context, recognising their tentative nature". Some candidates successfully used bullet points in their answer, which worked well.

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Examiner Comments

The response is brief and there is little detail included, but the essential points from the mark scheme are included.

(iii) These lyrics were famously contested by Dr Simon Singh in the Guardian newspaper. He argued that the correct age was 13.7 billion years, and disputed that scientists had guessed the age of the universe. As a result Katie performed the song with revised lyrics.

Discuss the suggestion in the song that values for the age of the universe are only guesses.

(3)

There is much dispute over the value of Hubble's constant because it is very diffiicult to measure distances in space and there is a certain amount of uncertainty. Therefore the age of the universe is not a guess, but there is large room for error.

(Total for Question 17 = 16 marks)

Question 18(a)

Most candidates were aware of the idea of resonance and how it was caused. A small number of candidates referred to “resonant frequency” rather than the correct term of “natural frequency”. In some answers the idea of the oscillation being driven or forced was missing.

Question 18(b)

This was generally well answered, although some candidates were unsure of the phase relationship between the various quantities and selected incorrect instants on the graph.

Question 18(c)

This was generally done well with a good appreciation of SHM formulae. The best answers recognised 70mm as twice the amplitude and stated the amplitude and formulae, and showed working and units at each stage. In some weaker answers “A” for amplitude was muddled with “a” for acceleration. It was disappointing to see a number of candidates who had otherwise answered the question flawlessly, but were unable to properly convert mm into m.

Question 18(d)

This question was high demand, and a large number of candidates failed to score well. The most common ‘errors’ were

- no reference to energy
- no mention of maximum energy transfer at resonance
- a reference to energy transfer but not to energy dissipation
- the importance of a phase shift to cancel out the oscillations
- the dampers changing the natural frequency of the bridge
- a muddling up of heavy and critical damping

Grade boundaries

Grade	Max. Mark	A*	A	B	C	D	E	N
Raw boundary mark	80	63	57	51	46	41	36	31

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