INTERNATIONAL AS/A-LEVEL PHYSICS

(9630) PH01 Mechanics, materials and atoms
Report on the examination

January 2022

REPORT ON EXAMINATION: INTERNATIONAL A-LEVEL PHYSICS (9630) PH01 MECHANICS, MATERIALS AND ATOMS – JANUARY 2022

There was a very wide range of marks for this paper indicating that the paper tested across the range of abilities of students. Although the mean marks for Sections A and B were comparable, the mean mark for Section C was higher than these.

Students generally fared better in the numerical questions than those requiring written answers. The technical language was often too imprecise to score in this qualification. Some questions ask students to “show that” a particular value can be obtained. Students should expect to produce an answer that rounds to the given value. In subsequent calculations, students are advised to use the given value unless their answer rounds to the given value.

QUESTION 01

Just over 50% of students obtained some marks for this question. The precision of technical language was insufficient from many students: “*Gravity energy*” is not an appropriate substitute for “*gravitational potential energy*”. The most common answer gave an accurate description of the transfers of kinetic energy from **X** to **Y**, with a partial description of the changes to the potential energies of the system. For instance, many students described a decrease in elastic potential energy from **X** to **O**, and an increase in gravitational potential energy from **O** to **Y**.

QUESTION 02.1

Some students confused “*no resultant force*” with the idea of “*no external force*” and gained little credit. Common incorrect responses described the idea of conservation of momentum or stated that the collision must be elastic.

QUESTION 02.2

A large majority gained full marks for this question by correctly assigning negative values to one direction of velocity. A significant number of students managed to deal with the vector nature of the calculation but were unable to complete the subsequent algebraic or numerical manipulation. For example, many took 0.8(0) + 0.15 to be 0.23. Correct answers given to only one significant figure were penalised by one mark.

QUESTION 03

This question discriminated reasonably.

QUESTION 04.1

About 40% of students knew the three products of free neutron decay. Those who gave further, incorrect products were penalised. Misspellings of “neutrino” were condoned here.

QUESTIONS 04.2, 04.3 and 04.4

These questions assessed students’ understanding of ideas relating to experimental procedures and were not well answered. Very few students used the provided information to compare the percentage uncertainties of each method (for 04.2) or to compare the overlap of values (for 04.4). Some students in 04.2 determined the percentage uncertainties but then referred to “accuracy” and denied themselves the mark. In Question 04.3, only about 10% of the cohort knew what “reproducible” meant in relation to an experimental measurement.

QUESTION 05.1

This relatively simple question provided a challenge to a surprisingly large number (about one-third) of students.

QUESTION 05.2

A large majority of students achieved some success with this calculation. The most frequent error seen was to use only two electrons when calculating the total charge. It was common to see the total mass determined correctly, for which students gained two marks.

QUESTION 05.3

Only about 20% of the cohort achieved both marks. References to positrons were penalised by one mark as the question is about a nucleus. Interestingly, one-mark answers of “*2 antiprotons, 2 neutrons*” were slightly more common than “*2 protons, 2 antineutrons*”. Perhaps students feel the lack of charge means there is no antimatter version of the neutron or that it is its own antiparticle.

QUESTION 05.4

Shortcomings in answers to this comparison were more common in the first marking point, where credit was given for stating that <u>both</u> annihilations would produce gamma radiation/photons, or two identical photons. Many students began their answer with a generic description of annihilation, without addressing the specific question. Marks were more frequently gained for the second and third marking points but, again, a lack of precision in language was commonly seen. For example, the second annihilation would produce “*bigger*” or “*more*” radiation. Answers that described the production of different numbers of photons received credit.

QUESTION 06.1

Just under 50% of the cohort gained one mark here. The expected mistakes were frequently seen: including failures to convert from grams to kilograms, or the use of weight rather than mass. Again, a sizeable number of students failed to gain credit for a correct method by giving their final answer to one significant figure.

QUESTION 06.2

Only about one-fifth of students gave an adequate description of a couple with a reason why the support forces could not constitute a couple. Most one-mark answers referred to the direction of the forces without explaining why this meant they could not be a couple.

QUESTION 06.3

This question discriminated well. The majority of scoring answers addressed only the first marking point by giving a statement about the clockwise moments being equal to the anticlockwise moments.

QUESTION 06.4

This relatively complicated calculation was too difficult for most students. Many, despite the preceding question, did not realise that the problem could be solved with balanced moments and tried to solve it geometrically using lengths alone. Those who did consider the relevance of moments often failed to appreciate the distribution of mass in the two sections and used lengths of 10 cm and 20 cm in their moment calculations.

QUESTION 07.1

Students must show clear working in “show that” questions. Examiners cannot be expected to infer parts of the solution. While few students read the micrometer scale correctly, they could still have gained two marks with a transparent manipulation of an incorrect reading. The best answers indicated why there was division by 3 to get a diameter, or by 6 to get a radius, and then clearly substituted into a stated formula for the area of a circle and multiplied by 7.

QUESTION 07.2

About half the cohort gained both marks for another “show that” calculation. Answers that gained one mark failed to give a subject for any working out. Purely numerical solutions for a “show that” question will rarely receive full credit.

QUESTION 07.3

Although very few students achieved full marks here, most gained some credit for relevant understanding of the physics. Students who simply divided the given tension by the mass of the load should have considered why that would be worthy of four marks. Credit was given for the conceptual steps. The most common incorrect step was to use only the mass of the load once they had determined the resultant force. The mass of the ropes, given in 07.2, was rarely included in $F = ma$.

QUESTIONS 07.4

Students answering a “deduce” question, such as this one, must present arguments that lead to a clear, and stated, conclusion. About 30% of students were successful at this. Those who presented inequalities such as “$160 < \frac{1}{5} \times 890$” did not gain the second marking point.

QUESTION 07.5

The conversion of MW h to J was the biggest difficulty here. About 25% correctly calculated the change in gravitational potential energy over 520 m for the load, with most including the mass of the ropes for this distance. However, they struggled to convert either their energy in J to MW h, or the given 4 MW h to J, and so could not make a valid statement about the claim. It was common to see 4 MW h treated as directly equal to 4 MJ. Those students who received no credit had often tried to calculate an elastic potential energy.

QUESTION 08.1

Few students addressed the question in detail or gave a reason for determining the background count at the start and end of the investigation. Most opted to explain why a background count is taken at all.

QUESTION 08.2

There was much success at this question. The inclusion of a unit with a correct answer was condoned this time. The most common incorrect numerical answer was 0.33.

QUESTIONS 08.3, 08.4 and 08.5

Most students had little trouble with 08.3, and nearly 60% plotted their values accurately. Far fewer drew an adequate line of best fit.

QUESTION 08.6

Many students made one comment about whether the graph supported the inverse-square law. Most pointed out that it was not supported as the line of best fit did not pass through the origin. Barely 5% of the cohort considered both the linearity and the y-intercept of their line.

QUESTION 09.1

This “show that” question was well answered by a majority of students. Students were credited for the first mark when it was clearly stated that they were equating the horizontal components of the tensions. As in 07.2, a subject for an equation was expected to be used. Purely numerical solutions were not credited.

QUESTION 09.2

Many students used trigonometry alone to answer this question and gained no credit. The question directed them to use a scale diagram. Very few students presented anything at the standard expected but they gained partial credit for attempts at diagrammatic solutions.

QUESTION 09.3

Marks were evenly distributed here. The first was for an accurate determination of a gradient to obtain the Young Modulus. Students should use as much of the linear section as possible when determining the value of a gradient. This was made more accessible by providing a graph that passed through the origin. Students often gained the second marking point by substituting into a form of the Young Modulus equation. Subsequent calculation errors in rearranging for the extension were often seen, depriving students of the final marking point. Again, a significant number of students produced a correct answer but then gave it with only one significant figure and did not get full credit.

QUESTION 09.4

Just over half the cohort correctly described the changes in the tensions in cables X and Y.

SECTION C

Students were, on average, more successful in this Section than in Sections A and B.
The questions found to be more challenging were: 17, 19, 20, 21 and 22.

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