2020 Physics Subject Assessment Advice

Overview

Subject assessment advice, based on the 2020 assessment cycle, gives an overview of how students performed in their school and external assessments in relation to the learning requirements, assessment design criteria, and performance standards set out in the relevant subject outline. They provide information and advice regarding the assessment types, the application of the performance standards in school and external assessments, and the quality of student performance.

Teachers should refer to the subject outline for specifications on content and learning requirements, and to the subject operational information for operational matters and key dates.

School Assessment

Assessment Type 1: Investigations Folio

This year, teachers were able to adjust their Learning and Assessment Plans, making use of the COVID flexibilities, however, the Investigations Folio still needed to include a minimum of two practical tasks and one Science as a Human Endeavour investigation. In the practical investigations, the students should have had at least one opportunity to deconstruct a problem for which the outcome was uncertain. They should then design a method to investigate one aspect of this problem. The method should not just be a repeat of existing methods.

Assessment design criteria to be used for this assessment type are Investigation, Analysis and Evaluation and Knowledge and Application.

Teachers should ensure that they are making decisions based on the current subject outline and the current performance standards when assessing their students’ work.

The more successful responses commonly:

* had a detailed deconstruction, giving deep consideration to multiple possible variables and a design that investigated one of them. They made full use of the four A4 pages that were permitted. The design was clearly identified, and justifications were shown (IAE1)
* proposed their hypothesis in an appropriate format rather than forms such as ‘The mass of a spinning wheel affects time taken’
* described logical and detailed method steps – with justifications given (sometimes in table format) – that could be implemented without further information (IAE1)
* identified factors which could not be controlled and why they could not be controlled (IAE1, KA4)
* included a table in their proposed method, indicating how the potential independent and dependent measurements could be recorded (IAE1, IAE2)
* clearly separated the four A4 pages of their deconstruction and design from the report on their investigation (KA4)
* utilised the specifications for a practical report (including the word count details) in the subject outline to present a report which addressed all the required aspects of their investigation in a critical and logical way (KA4)
* provided a clear interpretation of their results or data relevant to the investigation they have undertaken (IAE3)
* included a graph in at least one of the investigations, showing evidence of their understanding of the types of errors involved due to scatter of the data points around the line of best fit or gave a justified conclusion about whether the variables showed proportionality (IAE2, IAE3)
* constructed data tables that were easy to interpret and that followed conventions such as clear headings, units and correct significant figures (IAE2)
* critically evaluated their procedures by identifying an error as random or systematic, describing the cause of the problem, and specifically describing the impact that it has on their findings (IAE4)
* gave conclusions that were consistent with the results and indicated whether or not the hypothesis was supported (IAE3)
* justified their conclusion by referring to the data they had obtained and by considering the limitations of this conclusion due to the narrowness of their investigation (IAE3)
* based their Science as a Human Endeavour investigation on a contemporary discovery, innovation, or advance in science that was linked to one of the topics in Stage 2 Physics. They used the innovation to focus on one of the elaborations within a key concept to provide evidence of their understanding of the interaction between science and society rather than trying to cover the key concepts too broadly (KA3)
* expressed themselves using clear and concise expression and appropriate terminology (KA4).

The less successful responses commonly:

* involved heavily scaffolded deconstruction and designs where students simply filled in the blanks. This restricted the student’s potential to demonstrate depth in their problem-solving and creative deconstruction and design. (IAE1)
* simply gave a very brief introduction to the problem rather than a detailed deconstruction or did not identify the problem at all (IAE1)
* attempted to design an investigation had that no link to Stage 2 Physics (or even to the Stage 1 subject, which would not have been acceptable) (IAE1)
* ‘deconstructed’ a problem:
* for which the outcome was well-known (e.g. the effect of angle on the range of a projectile)
* led to the use of a well-known method (e.g. measuring the thickness or a hair)
* which was not really a *problem* to deconstruct (e.g. What are the properties of a transformer?) (IAE1)
* included no justification, based on physics concepts, of the chosen hypothesis and no justification of the materials selected or the steps included in the method (IAE1)
* only reported on investigations in which they were required to confirm a value, e.g. Planck’s constant, rather than reporting on investigations in which they used an independent variable and investigated its effect on a dependent variable (IAE2, IAE3, IAE4)
* presented the design of a method that could not be implemented. This was usually because there was simply insufficient information, for example, missing a list of the equipment required, missing specifications of quantities (weight, length, time), missing the steps to be followed, lacking information about the data to be collected (IAE1)
* presented investigation reports that included large numbers of tables and graphs which could have been summarised into a single table and/or graph if the appropriate data is selected. For example, separate data tables for measurements of different number of turns on a coil which could be summarised, averaged in one table and a single graph of the average results produced (IAE2)
* represented data in tables and/or graphs that:
* had incorrect column and row structure
* were labelled incorrectly (for example, with units repeated in cells) or lacked labels altogether
* omitted a column to show an average
* included data with inconsistent significant figures (IAE2)
* used the incorrect type of graph according to the data obtained. For example, using a bar graph when a line graph should be used, or using a dot-to dot graph when a line of best fit should be used
* selected incorrect scales. For example, a scale that progressed in different increments along an axis instead of equal space for equal values (IAE2).
* rather than describing the trend and analysing the data, repeated the information in the data table in words (IAE3)
* did not show how the analysis of their data was related to physics concepts (IAE3)
* identified improvements that could be made to an investigation, rather than critically evaluating the procedure (IAE4)
* included generic definitions of terms such as random error, systematic error, precision, and accuracy, rather than specifically identifying them and then discussing them in relation to the investigation that they had undertaken (IAE4)
* confused the terms precision, accuracy, random and systematic (IAE4)
* used generic responses in the evaluation of errors that could be applied to any experiment, for example, ‘miscalibration of instruments’, rather than identifying a specific systematic error that is likely to occur in the particular investigation being undertaken, and then explaining how it would affect the results (IAE4)
* misunderstood what was meant by the limitations that are referred to in the Science Inquiry Skills section of the subject outline (Recognise the limitations of conclusions). Students referred to aspects of the procedure such as running out of time or not having enough equipment, or group members not making correct reading. They have not recognised that limitations of the conclusion were confined to the limitations of the tests that they carried out. Examples of such limitations may include: only testing a small range of masses or having tested a single type of liquid or a single magnet (IAE4)
* exceeded the specified word count in their investigation report (KA4). Reasons for this included:
* putting an excessive amount of background research into their introduction
* not realising that the word count includes the hypothesis and any discussion of variables
* repeating the information in the data tables and/or graphs by describing them again in words before analysing them
* discussing improvements or enhancements, strengths and weaknesses.
* failed to make it clear which Science as a Human Endeavour key concept(s) they were discussing in the SHE report and hence the report lacked a focus and direction and thus becoming more of an information report rather than evidence of investigating the interaction between science and society (KA3, KA4)
* described the history of a piece of equipment (such as a laser) or a law (such as Keppler’s law) in the SHE report and passed it off as an example of the key concept of Development in SHE without relating it deeply to a recent innovation or discovery and the contemporary interaction between science and society (KA3)
* used images or illustrations in their SHE report without making any reference to them (KA4)
* selected complex concepts that did not link to a topic in the Stage 2 Physics subject outline to investigate for their SHE report. This made it difficult for students to demonstrate their understanding by giving clear explanations and often resulted in a rewording of an article that they have sourced (KA3, KA4)
* relied too heavily on ‘background science’ in the Science as a Human Endeavour report, rather than explicitly discussing the links to society through one aspect of a key concept (KA4)
* had not been guided effectively (KA4).

Teachers are reminded that copies of research materials and/or the evaluation of source material is no longer part of the evidence required in Assessment Type 1 and should not be included in uploaded materials.

It is recommended that teachers include an assessment of all the specific features that are relevant to the assessment type in their PSR.

Many teachers omitted a record of their assessment of KA3 in AT1, even though this is the prime Assessment Type for the assessment of this specific feature and it appeared to have been assessed on one or more tasks.

The specific features on the PSR should be congruent with those that have been assessed in the tasks and with what is recorded in the LAP.

Assessment Type 2: Skills and Applications Tasks

Three or four Skills and Applications Tasks provide evidence of students’ knowledge, understanding, and application of science inquiry skills, key physics concepts, and the connections with science as a human endeavour by discussing the interaction between science and society.

Assessment design criteria to be used for this assessment type are Investigation, Analysis and Evaluation and Knowledge and Application.

These tasks do not carry individual weightings.

The more successful responses commonly:

* showed that they could not only identify a particular concept, but also link the concept to a real-life application and explain themselves in a way that demonstrated that they really understand the concept. (KA2, KA4)
* clearly applied equations showing all working steps to solve problems (KA1, KA2, KA4)
* used diagrams, vectors and diagrams of fields to a high level (KA1, KA2, KA4)
* were facilitated by tasks that included a range of questions types – calculation, description, explanation, science inquiry (practical) skills, Science as a Human Endeavour connections rather than many calculations of the same kind and/or straight-forward questions that depended largely on recall (KA1, KA2, KA3, KA4).

The less successful responses commonly:

* reproduced textbook explanations rather than applied their knowledge to a specific context (KA2)
* did not show steps in calculations or tried to apply irrelevant formulae (KA1)
* resulted from students misinterpreting long, wordy questions (KA1, KA2)
* resulted when the tasks did not include related questions related to SHE and/or Science Inquiry Skills so that students did not have the opportunity to provide evidence for these specific features as is required in the subject outline (KA3, IAE)
* required students to respond to questions related to topics from the old subject outline (for example LADS, banking angles), reducing their evidence for the current subject outline (KA1).

Teachers should note that:

* percentages in tests do not automatically convert to particular grades within the performance standards.
* individual SATs do not carry weightings.
* a set of SATS should provide opportunities for students to demonstrate evidence of their understanding of Science as a Human Endeavour and Science Inquiry Skills.
* a decision for a particular specific feature in the PSR (for example KA3 or IAE3) should not be based on a single 2 to 4-mark question in one Skills and Applications Task. There should be enough evidence across the set of tasks to discriminate between student evidence of different quality.

External Assessment

Assessment Type 3: Examination

Some questions required students to show an understanding of science as a human endeavour and some required students to apply their science understanding from more than one topic.

Students were given a sheet containing symbols of common quantities, the magnitude of physical constants, some formulae, and standard SI prefixes.

Assessment design criteria used for this assessment type are Investigation, Analysis and Evaluation and Knowledge and Application.

Summary of examination advice for students

* Responses to ‘explain’ questions require far more depth than ‘describe’ questions. The underlying physics principles in a question need to be stated, then clearly related to the context using appropriate physics terminology.
* Questions that require calculations assess how well student can both answer questions and communicate their findings. All working (including unit conversion, rearrangement, and substitution) must be shown for responses to be awarded full marks.
* Derivations in physics show both mathematical skill and the ability to demonstrate an understanding of physics concepts. Any derivation must include a description of why a particular formula can be used, or a justification for using a formula made using physics knowledge and understanding.
* Each question must be read carefully. All information required to answer a question successfully, and efficiently, is found in either the stem of the question or in an accompanying diagram.

Question 1

Most students that undertook the paper were awarded marks for this question, particularly part (a) which was answered correctly by almost every student. The student responses to the later parts of the question showed that attention to detail continues to be a challenge.

The more successful responses commonly:

* showed all rearranging and substitution of values for parts (b) and (c)
* added the launch height of the projectile to determine the maximum height in part (c)
* explained how air resistance affects maximum height in terms of physics concepts of drag, acceleration, or time flight in part (d).

The less successful responses commonly:

* found the correct values for (b) and (c) by using a graphing calculator rather than communicating appropriate working as part of their answer
* described air resistance in general terms for part (d).

Question 2

As with Question 1, attention to detail was necessary to be awarded full marks for this question. Many students did not take the radius of the Earth into account when calculating the orbital radius for parts (a) and (b), and sometimes added the radius of the Earth incorrectly for part (c). Many students did not recognise that the term ‘hence’ suggests that answers to the previous part of the question ought to be used for the current part (for example, in this question, using part (a) to determine part (b)). Alternative methods for calculating the orbital speed in (b) were not penalised.

This question also highlighted that students need to assess the reasonableness of their answers. A significant number of students calculated orbital periods that were of the order 10–6 but did not question the likelihood of their answer and then did not reconsider their calculations.

The more successful responses commonly:

* added the radius of the Earth for the orbital radius in parts (a) and (b)
* showed all appropriate rearranging and substitution for all parts.

The less successful responses commonly:

* did not include the radius of the Earth for parts (a) and (b)
* did not use the gravitational force equation correctly (e.g. did not square r, used g rather than G)
* substituted incorrect values into a correct formula but did not check the result for part (a)
* did not convert km to m throughout the question
* converted kg to g throughout the question.

Question 3

This question gave students an opportunity to demonstrate their knowledge of electric fields. Most students were able to show the direction of the field correctly but were unable to sketch its shape.

The more successful responses commonly:

* showed electric field lines perpendicular to the surface
* showed widening arcs for the electric field lines

The less successful responses commonly:

* included a single line as their answer
* included a series of straight lines that did not strike the heating plate at right angles.

Question 4

This question provided students with an opportunity to show their experimental skills in the context of transformers. The student responses suggest that understanding of random and systematic errors is still challenging, as is the understanding of the effect of random and systematic errors on data in subsequent experiments. Many students did not use the gradient provided in the question to find a solution for part (a).

The more successful responses commonly:

* used the gradient of 0.080 to find the number of turns in the secondary coil
* used the relationship between primary and secondary voltages in a transformer correctly
* communicated that 0.080 was equal to the ratio of the voltage in the secondary coil to the voltage in the primary coil, and so was equivalent to the ratio of the number of turns in the secondary coil to the number of turns in the primary coil
* sketched a line in part (c) with the same vertical intercept and lower gradient.

The less successful responses commonly:

* calculated their own gradient using two points on the graph rather than use the gradient that was provided
* used points from the data table to calculate the value of the voltage in the secondary coil rather than using the gradient
* used the systematic error on the graph to determine an equation connecting the two voltages
* did not state that there was a systematic error in the data in part (b)
* drew a straight line in (c) that passed through the origin.

Question 5

Parts (a) and (b) of this question were relatively straightforward and were answered correctly by most students. In contrast, part (c) proved to be challenging. Students were directed to focus on the path of particle B, then use this to determine what adjustment was made to the experimental setup. Many students correctly linked the path to a lower acceleration, and hence weaker electric field, which then suggests that the potential difference was decreased. Other students discussed the decrease in vertical deflection of the particle using the path in terms of the work done moving through the field, which also suggested a decrease in potential difference. Either response was acceptable, however, many students did not give appropriate detail by drawing on mathematical relationships or physics concepts.

The more successful responses commonly:

* showed appropriate rearrangement and substitution for part (b)
* used appropriate physics concepts or relationships to justify their response in (c).

The less successful responses commonly:

* did not refer to the path of particle B in (c)
* did not use appropriate physics terminology for part (c).

Question 6

The cyclotron provides a context for students to demonstrate much of their understanding of the key concepts of Topic 2. The student responses suggest that the cyclotron is still not well understood, and that derivations are rote-learned without regard for the physics principles or concepts that underpin them. Very few students were awarded full marks for this question, however, those who were awarded full marks for (b) tended to also achieve at a high standard for the rest of the paper.

The more successful responses commonly:

* correctly identified the magnetic field directed out of the page for part (a)
* described why the formula  could be used with  by explaining that the charged particle undergoes circular motion within the dees of the cyclotron
* showed all appropriate rearrangement and substitution for part (c).

The less successful responses commonly:

* used a ‘solver’ function of the graphing calculator rather than communicating appropriate mathematical working for part (c)
* provided a derivation in (b) that did not include any explanation about why particular formulas were used.

Question 7

The structure and style of this question has been commonly used, but still proves challenging for students. The responses suggested that students cannot determine the energy difference between energy levels accurately; are confused by the negative values given on the diagram; and cannot convert energy in  to energy in J.

The more successful responses commonly:

* drew a single arrow directed downwards that ended on the  energy level
* showed appropriate conversion from  to J in (b)
* showed all appropriate rearrangement and substitution.

The less successful responses commonly:

* drew multiple arrows in part (a).
* drew lines that did not indicate a direction in part (a)
* calculated wavelength instead of frequency
* did not convert  to J.

Question 8

Answers to this question required more detail than was given by many students. A large number of students gave a general reason but did not refer specifically to the context and physics concepts. In a similar way to earlier questions, the responses to part (b) students often did not include appropriate rearrangement and substitution. As referred to in Question 2 (b), many students gave unrealistic values for the charge of a particle.

The more successful responses commonly:

* provided a correct answer (A) and provided a reason that used a proportionality relationship or coherent physics principle
* showed appropriate rearrangement and substitution for part (b).

The less successful responses commonly:

* used  and  incorrectly to argue that B has the larger mass
* used the ‘solver’ function on the calculator rather than showing appropriate working.

Question 9

This question appeared to simple but required students to integrate complex ideas.

For part (a), students needed to explain the acceleration using the conservation of momentum. Therefore, they needed to link the law of conservation of momentum to the change in momentum of the rocket; then link the change in momentum to either a force or change in speed. Finally, they needed to link the force or change in speed to acceleration.

Few students communicated these links clearly, and most students did not state the law of the conservation of momentum correctly.

Part (b) was answered poorly. Students needed to explain that since the rocket moves at a constant speed, then the net force is zero and thus the force due to gravity must be equal to the force applied to the rocket. The calculation that follows is just one part of a complex question.

The science as a human endeavour (SHE) question also proved challenging. Students were able to identify and discuss the SHE strands, but many students had difficulty explain the strands in the context of the question. Clear links between the response and the information needed to be made for a response to gain full marks.

The more successful responses commonly:

* explained the links between physics concepts clearly and explicitly for parts (a) and (b)
* used parts of the diagram in (c) to assist their explanation of the SHE strands rather than form the entire response
* stated the SHE strands clearly at the beginning of their response in (c).

The less successful responses commonly:

* did not use the law of conservation of momentum in (a)
* did not describe the balancing of the forces in (b)
* described the SHE strands without context in (c).

Question 10

This question required students to be familiar with Kepler’s First Law. Many students were unable to articulate why the star was located at X and attempted to use Kepler’s Second Law to explain their reasoning.

The more successful responses commonly:

* correctly stated Kepler’s First Law and related it to the context in the question.

The less successful responses commonly:

* attempted to discuss the speed of the comet.

Question 11

This question highlighted the challenges for students to differentiate between double slit experiment formulas and diffraction grating formulas.

Part (a) required a simple trigonometric calculation using the diagram but many students appeared to ignore this instruction. Many students attempted to use  but this expression may only be used when the small angle approximation holds in the double slit experiment and not in a diffraction grating experiment.

Many students appear to have difficulty calculating the distance between slits given the lines per mm in a diffraction grating.

The more successful responses commonly:

* used the diagram to calculate the angular position
* recognised that 0.980 m needs to be divided by 2
* clearly explained why the maximum possible angle in (b) was 90 degrees
* rounded their calculated value for m down to the nearest integer.

The less successful responses commonly:

* did not refer to the diagram in (a)
* used incorrect formulas for (b)
* did not recognise unrealistic values for m.

Question 12

This question required students to have a good understanding of the physics principles behind an X-ray tube and not just a good understanding of the mathematical formulas. Students did not appear to have a good understanding of how X-rays are produced at the target, as many responses did not refer to energy conversion or accelerating charged particles.

Many students incorrectly used formulas related to the photoelectric effect in this question. Students needed to understand that even though the same numerical answer follows from a calculation using , this does not demonstrate good physics understanding.

Part (e) proved to be challenging. Students were able to recognise that the maximum frequency and characteristic peaks were constant, and many described a decrease in intensity, but were unable to link this to the filament current. This suggests that students did not have a good understanding of the components of an X-ray tube and how each of these components affect the X-ray spectrum.

The more successful responses commonly:

* explained the purpose of the target in terms of physics principles
* used correct physics understanding to calculate the correct value for (b)
* showed appropriate rearrangement and substitution for (b) and (c).

The less successful responses commonly:

* used the ‘solver’ function on the graphing calculator
* discussed ‘voltage’ in general terms in part (e) rather than explaining that they meant the voltage over the X‑ray tube or the voltage over the filament
* confused which line in (e) was the line after the adjustment was made.

Question 13

This question provided another opportunity for students to show their experimental skills.

The responses suggest that students have difficulty with accuracy and precision (as distinct from resolution).

Lenz’s Law and eddy currents continue to be difficult concepts for students to understanding and articulate. Many students were able to describe that there is a change in magnetic flux in (a)(i) but were unable to explain clearly how this change in flux gives rise to eddy currents in the coin.

Similarly, few students were able to use the conservation of energy to explain why the coins slow down as they passed through the magnetic field. Students needed to link the energy in the electric current with the kinetic energy of the coin.

The more successful responses commonly:

* used Lenz’s law as part of their answer to (a)(i)
* clearly stated the direction of the change in magnetic flux in (a)(i)
* explained the effect of error on data in (c)(i)
* referred to scatter in (c)(ii)
* stated the law of conservation of energy in (b) then discussed it in the context of the question.

The less successful responses commonly:

* gave confused descriptions of Lenz’s law
* did not use the law of conservation of energy in (b)
* confused precision of data collection with the resolution of the measurement device.

Question 14

This question allowed students to show their understanding of vectors in the context of electric fields.

Many students did not convert micro Coulombs to Coulombs in part (a), which suggested that students did not perform the calculation.

Many students were not able to show the vector diagram correctly in part (c) and incorrectly assumed that the vector diagram would form a right-angled triangle.

The more successful responses commonly:

* performed the calculation to show a correct value in (a)
* drew appropriately sized vector diagrams in (c)
* provided a justification for their final value in (c).

The less successful responses commonly:

* did not convert units correctly
* used the electric field formula incorrectly
* drew small vector diagrams in (c).

Question 15

This question, while fairly straightforward, showed the importance of attention to detail in physics explanations and reading a question.

Many students were unable to use explicit physics terminology to explain the dark fringes. Students needed to clearly articulate that the path difference between the rays was a half-integer multiple of the wavelength which resulted in destructive interference, observed as a dark fringe.

One- or two-word answers were not sufficient to gain full marks for this question.

In part (b) many students did not recognise the distance between the central maximum and A was  and others attempted to use .

The more successful responses commonly:

* used explicit physics terms
* converted cm to m correctly.

The less successful responses commonly:

* described rather than explained the presence of dark fringes
* did not convert units
* did not recognise an unreasonable value for the wavelength.

Question 16

This question also showed that student needed to read the questions carefully to achieve full marks.

Many students:

* substituted the threshold frequency from (a)(i) into the photoelectric effect formula in (a)(ii) even though it was not required
* did not convert  to J in either (a)(i) or (ii).

Student responses suggest that Einstein’s explanation of the photoelectric effect was not well understood, or least not able to be clearly articulated.

The more successful responses commonly:

* converted  to J throughout the question
* used the correct frequency in (a)(ii)
* described Einstein’s explanation of the photoelectric effect in terms of a single photon.

The less successful responses commonly:

* confused the frequency in (a)(ii)
* did not convert  to Joules.

Question 17

Part (a) of this question proved to be challenging for students.

Students can find rearranging formulas difficult, and this is likely to be the most difficult in the course.

When ‘showing’ a value, students needed to be clear in their reasoning and the steps shown.

In this question, students were required to rearrange a challenging formula, substitute correctly, and arrive at the correct solution. Many students did not appear to have performed the calculation as the formula was rearranged incorrectly.

In part (b), students needed to correctly identify each of the distances with respect to length contract then perform the calculation. Many students were awarded full marks for this question.

The more successful responses commonly:

* showed careful rearrangement and substitution in (a)
* used femtometres correctly in (b).

The less successful responses commonly:

* showed little working for (a)
* substituted  to attempt to calculate a Lorentz factor of  in (a).

Question 18

This question showed that students have been learning the Standard Model to appropriate detail.

Students were required to understand the conservation of both electronic and muonic lepton numbers and explain how these relate the context in the question. Many students were awarded full marks for this question.

The more successful responses commonly:

* clearly explained that electrons and electron anti-neutrinos only have electronic lepton numbers and not muonic lepton numbers
* used the conservation laws correctly.

The less successful responses commonly:

* confused the sign of lepton numbers
* attempted to conserve numbers in the rows rather than the columns.