May 2022 subject reports

Biology

Overall grade boundaries

Please note that the boundaries set during the May 2022 session reflect the exceptional circumstances and challenges faced by schools during the pandemic. If using this year's examination to determine future students' grades in mock examinations, we recommend you consult the boundaries that were set in previous sessions.

Grade:	1	2	3	4	5	6	7
Mark range:	0-14	15-28	29-40	41-49	50-59	60-68	69-100

General comments

Feedback shared by teachers, candidates and examiners following the exam was again overwhelmingly positive, praising the interactive nature and creativity demonstrated in the assessment. In addition to offering valuable guidance in establishing grade boundaries, feedback from teachers assists in developing future assessment tasks. Teachers are actively encouraged to provide feedback on the exam in future sessions; schools could facilitate this by ensuring teachers have access to the exam and dedicated time to do this. Although more challenging than last session, the difficulty of the exam was thought to be appropriate. The clarity of the questions and interactive media rated either good or very good. The exam accurately reflected the published topic list. There continues to be an improved understanding of the assessment blueprint amongst teachers and candidates; in particular, the equal weighting of the four assessment criteria within the exam. A higher number of teachers than last year felt that the exam was long, however most candidates felt it was appropriate in length and were able to finish in good time. It offered candidates the opportunity to demonstrate their knowledge and skills in MYP Biology.

Examiners commented that relatively few questions were left unanswered and the expected range of quality in candidate's responses was again observed.

The areas of the programme and examination which appeared difficult for the candidates

Candidates found the following areas difficult:

- Digestion; the differences between chemical and physical digestion, the relationship

between structure and function of the small intestine.
- Human interactions with environments: the causes and consequences of eutrophication, the identification of direct and indirect sources of pollution.
- Appropriate use of terms such as validity, reliability, representative, accuracy, and precision when referring to methods used, and data collected in scientific investigations.
- Planning to include an experimental control.
- Processing of data beyond the calculation of a mean; the calculation of stomatal density, rounding to an appropriate degree of accuracy.
- The structure and function of enzymes when applied to an unfamiliar context.

The areas of the programme and examination in which candidates appeared well prepared

Candidates were well prepared for the following areas:

- Cells; the differences between plant, animal and bacterial cells, the identification and function of organelles.
- The identification of independent, dependent, and control variables in structured and unstructured scientific investigations, and the use of these to generate and improve research questions.
- The use of interactive media to support the planning of scientific investigations.
- The use of data to calculate means and draw basic conclusions to scientific investigations. The difference between qualitative and quantitative data.
- The identification of and selection of relevant arguments to support conclusions.

The strengths and weaknesses of the candidates in the treatment of individual questions

Question 1

1(a) Most candidates answered correctly.

1(b) Although most candidates suggested valid questions, some asked questions that did not have yes/no answers or referred to the colours or shapes used in the images. Some candidates did not frame their answers as questions, yet still gained credit for showing understanding of the differences between plant and animal cells.

1(c) Most candidates answered correctly. A reasonably common incorrect response was ‘ribosome’.

1(d) Most candidates gained the mark with the first marking point. Common errors included reference to protection. A number of candidates incorrectly identified the structure as the cell wall (referring to this by name in their answers) and proceeded to suggest functions relating to this structure instead. Occasionally the cell membrane was correctly identified but no function provided.

1(e) Most candidates could state that tissues are made of cells but far fewer developed their answers to discuss similarities between cells and cells working together for a common function.

Question 2

2(a) Most candidates gained both marks. The nervous system was occasionally confused with the circulatory system.

2(b) Generally well answered by candidates.

2(c) Many candidates had the correct idea of breaking food into smaller pieces, although references to breaking down particles, or even molecules, showed some confusion between mechanical and chemical digestion. Few candidates explicitly said it was to make food easier to swallow, but many said it would pass more easily down the oesophagus or into the stomach. There were references to softening, lubricating or moistening the food that were not always explained. Stronger candidates referred to the increasing surface area of the food. In the rare occasions where candidates referred to enzymes or digestion, they were often not detailed or specific enough to secure the final marks.

2(d) Most candidates were correct (usually with 'sugar', 'glucose' or 'maltose'); however all food types were seen. Starch was a common incorrect response.

2(e) Many candidates named or described villi and microvilli (although there was some confusion with cilia and the idea that they 'catch' food as it passes along). Although many mentioned blood (e.g. 'capillaries') few clearly described a 'good' blood supply. There were various descriptions of the thin lining but these weren't always very clear. A relatively small number of candidates mentioned lacteals. Better answers clearly linked structure to function; described a large surface area, maintaining a concentration gradient, or referred to a short diffusion gradient.

Question 3

3(a) Many candidates answered this correctly, often referring to dead plants and animals or soil. A common error was simply stating the name of a nutrient provided in the question, for example nitrogen.

3(b) Despite the support from the interactive media there was lots of confusion between direct and indirect sources of nutrients. Many candidates appeared to guess, with different types of runoff commonly being suggested for both sources.

3(c) Many candidates gained the first marking points for the sources of nutrients and link to the algae. The third marking point was awarded less frequently; candidates commonly repeated information from the question stem rather than providing a mechanism for the increase in algal population.

3(d) Although some excellent answers were seen from candidates, the topic of eutrophication was generally poorly understood. When marks were awarded, the first marking point referring to the blocking of sunlight was most common. The impact of reducing oxygen levels was often credited but was rarely the correct mechanism. Some candidates thought that the drop in biomass was caused by fish leaving the area to escape the algae.

Question 4

4(a) Most candidates correctly identified colour as the independent variable.

4(b) The ideas of volume and time were frequently seen, but not always the difference in volume. Weaker candidates simply repeated the units stated in the question, without giving sufficient information as to how the measurements would be taken.

4(c) This was generally well answered by candidates. A common error was to suggest unqualified variables ‘temperature’, ‘time’ or ‘light’ where it was not explicit what was being referred to. Others incorrectly suggested the volume of water, which for the given set up would not have mattered as it was clearly in excess.

4(d) Candidates were generally able to suggest improvements made to the research question by group 2. Justifications were more difficult, and therefore less well done. The most common error was stating that group 2 had written their research question as a question and group 1 had not; research questions can be testable statements. A few candidates misread the question and offered their own additional improvements to the research questions.

4(e) Many candidates gained marks for commenting on the inclusion of a control and how this can be used to see the effect of the dyes. Candidates also picked up on the results from group 2 being presented to two significant figures/one decimal place but were for the most part unable to justify this in terms of precision, frequently referring incorrectly to accuracy and reliability.

4(f) Most candidates gained this mark; although the language used in responses was not always particularly scientific.

4(g) Candidates found this question quite challenging. Many thought sealing the beakers meant covering the whole experiment so that the plant was sheltered from wind or its temperature was controlled.

Question 5

This question saw the expected variety in both the quality of answers given and the marks gained. Answers ranged from lengthy step-by-step descriptions, gaining many of the marks, to short answers that did not properly address all the points identified in the question. Most answers logically followed the structure encouraged by the question. Candidates are unlikely to have conducted all of the investigations they may be expected to plan in the assessment; they will have to plan unfamiliar tasks and should expect use the accompanying media for support.

Variables: Despite the information in question 4b (the rate of transpiration cannot be measured directly; it must be calculated from the dependent variable) many candidates identified the dependent variable as rate of transpiration without further clarification of how this would be measured. Most candidates identified windspeed as the independent variable. Control variables were generally well identified, but as in 4c these were not always sufficiently qualified: temperature would gain no credit, whereas temperature of the water or environment would.

Hypothesis: Many candidates gained two marks here for correctly linking the appropriate variables. Very few candidates were able to support their hypothesis with a correct scientific explanation.

Manipulation/Method: Methods varied from lengthy, detailed, step-by-step descriptions to vague summaries. Stronger candidates gave clear details for each of the variables identified, as well as providing additional details (quantities, measurements etc.) that made the method repeatable.

Data: Most candidates intended to conduct at least three trials, with many also suggesting five different values for the independent variable. The inclusion of a control condition within or in addition to this range of five conditions was infrequently seen.

Justification: Many candidates planned to calculate means and/or rate of transpiration, but few gave valid justifications. Some described how to calculate the change in volume using potometer readings.

Safety: Many candidates gained the mark for a relevant safety consideration. A generic statement that was not linked to the specifics of this investigation (wear goggles, tie hair up) did not receive any marks.

Question 6

6(a) Most candidates scored 1 mark, often referring to means or accuracy, or bias, but rarely both. Very few candidates considered why a sample is taken as opposed to measuring stomatal density for all leaves on a plant.

6(b) Marks were commonly given for leaves being dead, damaged, cut or withered.

6(c) The majority of candidates gained the mark for counting the stomata in the image.

6(d) Most candidates scored the first mark for calculating the mean. A large number of candidates stopped here. For those who completed a stomatal density calculation using the equation given, a second mark was commonly awarded. Very few candidates gained a third mark for giving their answer to an appropriate degree of accuracy.

6(e) Most candidates gained this mark. The most common incorrect response was ‘quantitative’, suggesting the question had not been read properly.

6(f) Most candidates gained the mark for growing underwater. However this was often accompanied by an unnecessary and incorrect explanation.

6(g) Candidates were able to effectively state the similarities and differences in the distribution of stomata across the two leaves, often stating numbers to support the points being made. Explanations beyond there not being stomata present on the bottom of water lilies because they are in contact with the water were seldom seen.

Question 7

7(a) Most candidates correctly identified the definition corresponding to food web, with food chain being the most common incorrect answer.

7(b) Candidates struggled to connect the structure and function of enzymes to the breakdown of plastics and often recalled knowledge. The best answers showed an application of knowledge, discussing catalysis and substrate specificity in terms of the rapid breakdown of specific plastics. Marks were frequently awarded for use of correct terminology.

7(c) Most candidates answered this question correctly. Where only one mark was awarded, the second and third boxes were often inverted.

Question 8

8(a) The majority of candidates were able to effectively use the media to select relevant information, but rarely expanded upon this in sufficient detail. A few candidates misunderstood the question and discussed the need for recycling or the impacts of plastics, rather than the different methods of recycling.

Properties and uses: Most candidates could describe some properties and uses, but rarely linked the two sufficiently. Cheap price was also a common response, but this was not credited as a physical property.

Environmental consequences: Most candidates correctly selected information from the media, often referring to the limited number of times plastics could be recycled mechanically (and thus ending up in the environment) or the energy needed in chemical recycling. Rarely did answers go beyond statements; often leaps were made by candidates that were not explained and relied on examiner understanding. For example, candidates frequently discussed the energy needs of chemical recycling as a cause of global warming, without discussing the burning of fuels and release of greenhouses gases to support the claim.

Economic impacts: Most candidates correctly selected information from the media, commonly stating that mechanical recycling was cheaper than chemical or biological recycling. These statements were frequently then not developed with sufficient further discussion.

Concluding appraisal: Most candidates suggested a method for the recycling of plastics supported by relevant information, often comparing the three methods. No credit was given for conclusions that did not support a particular method, but instead supported recycling as a whole

8(b) Candidates offered many valid suggestions and justifications. Common responses included: reducing use of plastics, using alternatives, reusing, using biodegradable plastic. Raising awareness and imposing fines or taxes were also seen. The most common errors were to write about recycling or offer the same suggestion twice.

Recommendations and guidance for the teaching of future candidates

Teachers must continue to use the full range of MYP command terms in their teaching and assessment, to enable candidates to become more familiar with what is expected of them in terms of level. In addition, teachers should model how to answer questions using higher level command terms such as explain, discuss and evaluate, justify, and compare and contrast to help candidates develop these skills.

Teachers must expose candidates to a range of varied, open-ended practical tasks as well as partially completed lab plans and data sets during their MYP studies. Candidates should not be surprised when unfamiliar investigations are presented in the examination.

Teachers could focus on and model different aspects of the scientific method; it is not always necessary to complete the full process to practice the skills needed.

Candidates must be given opportunities to construct research questions and hypotheses, as well as to evaluate and improve them.

Teachers can provide candidates with data sets that encourage candidates to support and reject hypotheses to differing extents. Authentic data can and should demonstrate a range of different relationships. Opportunities for meaningful processing of data should be planned for, beyond that of calculating the mean.

The selection of pieces of equipment or experimental techniques should be discussed in terms of accuracy, precision and reliability and the impact on the validity of the data should be explored using the correct terminology. The inclusions of controls should be more commonplace.

Candidates must be taught the difference between improvements or extensions to experimental methods.

Teachers must provide candidates with regular opportunities to engage with source material linked to real world issues.

Candidates need time to plan and produce extended responses where they are challenged to consider relevant factors beyond the environment and economy.

Teachers must model how information found in source material can be identified and subsequently used as a starting point for further justification and developed accordingly. The interactive media and questions in the exam can be used to support this.

Teachers could model how to breakdown big questions into smaller parts.

Candidates should practise using the bullet points to structure their answers and ensure all parts of the question are covered.

Teachers should work with candidates to develop writing strategies that encourage candidates not to repeat the question in their answers.

Schools should make use of the past exams available and the familiarization material, ensuring that candidates are familiar with the style of the on-screen presentation and have experience interacting with the different tools and available media.

Chemistry

Overall grade boundaries

Please note that the boundaries set during the May 2022 session reflect the exceptional circumstances and challenges faced by schools during the pandemic. If using this year's examination to determine future students' grades in mock examinations, we recommend you consult the boundaries that were set in previous sessions.

Grade:	1	2	3	4	5	6	7
Mark range:	0-20	21-40	41-55	56-64	65-73	74-82	83-100

General comments

Feedback from teachers stated that the assessment provided a range of questions which allowed both access to lower ability candidates and challenge to higher ability candidates. The examination team agreed that the assessment tasks were fair, linked to the topic list and assessed the MYP assessment criteria.

The length of the examination was suitable for the candidates with good foundation in the topics covered within chemistry. Some candidates, however, noted that they did not have enough time to complete the examination.

The areas of the programme and examination which appeared difficult for the candidates

The areas of the programme and examination which appeared difficult for the candidates included the following:

- Naming compounds from formulae and writing formulae from names.
- Outlining the test for oxygen
- Determining the number of moles from the mass of a substance.
- Presenting graphs correctly with scales that showed suitable increments and correctly plotted data.
- Determining correct units when calculating rates.
- Determining the correct number of significant figures with answers.
- Determining how rates of reactions are different for solutions or solids.
- Determining whether a reaction was exothermic or endothermic based on the outcome of an investigation.
- Relating average data to actual data and make suitable inferences about its validity.
- Linking the hazard symbol of a reactant and suitable safety precaution that should be carried used in an investigation.
- Using scientific terminology including specific terms such as "volume" and "mass". Candidates should avoid writing vague terms such as "amount" or "quantity".

The areas of the programme and examination in which candidates appeared well prepared

The areas of the programme and examination which candidates appeared well prepared are:

- Identifying elements in the periodic table
- Identifying atomic number and mass number from the periodic table
- Determining the balanced equation from information provided.
- Identifying the pH of a solution as acidic
- Planning investigations and identifying suitable variables
- Extracting relevant information for analysis and discussion.
- Identifying average volumes and identify errors in investigations
- Identifying of dependent, independent and control variables.

The strengths and weaknesses of the candidates in the treatment of individual questions

Strengths

Question 1

Candidates were able to identify properties of elements, determine the element from its electronic structure.

Question 2

Candidates were able to identify the position of an element from the group and period given, determine the model of a given formula for an organic molecule, determine the pH of a solution.

Question 3

Candidates were able to identify Lewis structure from diagrams, able to identify which method was suitable for cleaning contact lenses.

Question 4

Candidates were able to determine variables and calculate average volumes of gas produced.

Question 5

Candidates were able to design an investigation for an unfamiliar problem.

Question 6

Candidates were able to interpret unfamiliar information provided about the action of hydrogen peroxide on hair, graphing of data and use the graph to make predictions.

Question 7

Candidates were able to identify the appropriate properties of paper for an application as well as identifying the reasons why toxic chemicals were not a good idea to use in paper production. Candidates were able to interpret data to show the advantages and disadvantages of two different types of paper production.

Question 8

Candidates were good at identification of environmental and economic impacts using information provided as well as wider MYP studies.

Weaknesses

Question 1

Candidates struggled with the determination of the mass of an isotope and calculation of moles from a known formula.

Question 2

Candidates struggled with mole calculations, determination of temperature changes with diagrams and determining the balanced equation when provided with information about reactants and products.

Question 3

Candidates struggled to correctly identify hazard symbols and struggled to interpret data from graphs.

Question 4

Candidates struggled to outline the test for oxygen, produce a hypothesis relating state of a catalyst to the rate of reaction and determine the validity of a hypothesis. They also struggled with determining reasons for experimental error.

Question 5

Candidates struggled with ensuring suitable data was collected, determining the dependent variable and selecting additional equipment to complete the investigation.

Question 6

Candidates struggled with labelling axes correctly and producing scales which showed even increments and labels. Candidates struggled to understand the validity of an average value and how this could be applied to a real-world situation.

Question 7

Candidates found it difficult to analyse data and use this to justify which paper was best for long-term document preservation.

Question 8

Candidates found it difficult to provide a justification as well as a conclusion after considering economic and environmental comparisons of paper production.

Question 9

Candidates struggled to identify advantages and disadvantages of paper and electronic storage.

Recommendations and guidance for the teaching of future candidates

Teachers should use past assessments with markschemes to understand what is required when candidates answer questions.

Familiarisation of the package used for the on-screen examination should be undertaken so that candidates are able to use their time wisely in situations such as producing graphs.

Candidates should be taught how to make suitable hypotheses with the information provided and should understand the meaning of validity.

Candidates should be familiar with the command terms and understand what that means in terms of the complexity of the answer provided.

Candidates should be comfortable in exploring situations which are unfamiliar.

Candidates should be taught how to derive units and what understand the importance of appropriate significant figures.

Integrated sciences

Overall grade boundaries

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Grade:	1	2	3	4	5	6	7
Mark range:	0-10	11-21	22-39	40-47	48-56	57-64	65-100

General comments

This Integrated Sciences on-screen examination was developed considering the four assessment objectives and criteria, key and related concepts, the topic list, and skills for the sciences. The global context developed was personal and cultural expression and it was covered in questions 4 and 5 as these emphasized the idea of how artists have used many ways to express their ideas, feelings and creativity.

Based on comments from teachers, the general structure of this exam was about right and allowed candidates to demonstrate a wide range of knowledge and skills through the exam.

The comments also indicated that there was good coverage of the assessment objectives and criteria. Also, the use of media and stimuli material was clear and appropriate for candidates.

Finally, most teachers stated that the language and accessibility and the time frame for the exam were fair for all candidates.

The areas of the programme and examination which appeared difficult for the candidates

There were different parts of the test that seemed to be difficult for the candidates, for example:

Explaining chemical and biological processes together to provide an answer, for example the difference in the mean number of mitochondria found on muscle cells compared to fat and skin cells or selecting the graph and justification on the initial digestion of proteins or explaining how an exercise demonstrated the Newton´s third law of motion.

Identification of the control variables in the investigation about the size of crystals formed by dissolving different compounds.

Unit conversion, in this case from grams to milligrams.

Formulation of a testable hypothesis for an investigation using the “if, then, because” structure.

Identifying additional equipment was also difficult. Some candidates thought that the hot plate could be used to measure exactly the temperature of the water, so the thermometer was not mentioned as an additional piece of equipment.

Stating weaknesses in the method and suggesting improvements in the investigation about particulate pollution.

Stating an extension to the investigation about particulate pollution.

The areas of the programme and examination in which candidates appeared well prepared

- Designing a lab investigation. Most candidates were completely able to plan an experiment according to the information provided.
- Candidates were able to identify dependent, independent and control variables in the investigation.
- Candidates appeared to be well prepared to present transformed data in a bar chart. Candidates were able to state a correct title, correct name of the axes, an appropriate scale and plot values correctly.
- Candidates appeared to be well prepared to answer short and extended responses. Most of the candidates used the prompts provided in the questions to organize their ideas.

The strengths and weaknesses of the candidates in the treatment of individual questions

The following comments are made on individual questions.

Question 1

For question 1(c), some candidates were able to suggest and justify a reason for the difference in the mean number of mitochondria found in muscle cells compared to fat and skin cells using specific scientific terminology.

For question 1(d), candidates found it difficult to identify the graph that represents the enzyme responsible for the initial digestion of the protein linked to the pH value and justify the answer based on the acidic conditions in the stomach.

Question 2

For question 2(e), some candidates were not able to calculate the work done by the athlete when lifting the barbell. This topic could be covered by reviewing energy transfer. In this question, the work done was a change in the gravitational potential energy of the barbell.

For question 2(f), some candidates found it difficult to explain how an exercise demonstrates the Newton´s third law of motion.

Question 3

For question 3(a), most of the candidates were able to identify the energy transformation taking place in the treadmill as the athlete is running.

For question 3(b), most candidates did not get full marks when calculating the resistance generated by the motor since they did not provide the answer to two significant figures only.

For question 3(c), most candidates were not able to explain why the concentration of lactic acid in blood changes with running speed.

Question 4

For question 4(a), most candidates were not able to explain why crystals had been formed after a saturated solution was prepared.

For question 4(b), some candidates were not able to identify control variables in the investigation about the size of the crystals formed by dissolving different compounds. The dependent variable was given to the candidates.

Question 5

For question 5(a), most candidates were able to formulate a testable hypothesis for an investigation using the “if, then, because” structure.

Most candidates performed very well in question 5(b). Most of them identified the independent, dependent and the control variables in this investigation. Some candidates did not state that a thermometer was required in the experiment as an additional equipment since the hotplate did not measure the temperature, just changed it. Besides this, most candidates earned many marks indicating five different initial temperatures and at least three trials. Finally, most candidates were able to state a safety precaution linked to a specific hazard with regards to the experiment.

Question 6

For question 6(b), most candidates were able to present the transformed data in a bar chart, giving an appropriate title, correct name of the axes, appropriate scale and values plotted correctly.

For question 6(e), most candidates were able to earn 2 or 3 marks out of 4. This question required the evaluation of the hypothesis and the use of the data provided to support the answer.

For question 6(f), most candidates were not able to correctly state two weaknesses in the method and suggest improvements for the investigation about particulate pollution in different part of a city.

Question 6(g) asked to how to extend an investigation. This was particularly difficult for most candidates as they were not able to provide an alternative independent variable. A few candidates could get the mark.

Question 7

For question 7(b), most candidates were able to use the information from the table to identify one nutritional benefit of corn compared to rice and justify how this nutritional value would improve health.

Question 8

Candidates seem to be very well prepared to answer this holistic question related to the use of Bt corn and conventional corn. It was clear for the examining team that the prompts provided in the question proved to be a good help for candidates. Many candidates demonstrated excellent critical thinking and communication skills.

Some candidates answers were limited as they did not provide clear advantages or disadvantages of Bt corn related to the **environment**. Some of them just stated general advantages or disadvantages of the production of Bt corn.

Recommendations and guidance for the teaching of future candidates

Candidates need to be familiar with the use of media resources and stimulus material (interactive tools, videos, graphics, images, others).

Candidates need to be aware of the importance of the correct use of scientific terminology: correct use of the units, appropriate names of variables. For example, it is not “amount of water”, it is “volume of water”.

Candidates need to be aware of the importance of giving final values considering appropriate numbers of significant figures.

Candidates should be able to write a complete method, fully described that could be easily followed. If required, the method should include all variables and must state 5 values of the independent variable, 3 trials and a plan to calculate an average.

Candidates should be able to write a complete hypothesis and explain it using scientific reasoning. Use of the “If, then, because” structure could help candidates to write this appropriately.

Candidates should be able to state additional equipment, if required, according to the investigation.

Candidates should be able to collect a full range of data according to the information or simulation provided.

Candidates should be able to determine an extension of an investigation by modifying the independent variable.

Candidates should carefully read the question and use all the information provided, especially the prompts, to answer extended/holistic responses.

It is highly recommended to use the familiarization material provided by the IB to enhance candidate preparation for the exam.

Physics

Overall grade boundaries

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Grade:	1	2	3	4	5	6	7
Mark range:	0-13	14-27	28-44	45-55	56-65	66-75	76-100

General comments

The on-screen examination this year involved interesting and relevant contexts for the candidates to explore and apply their knowledge of Physics. It was pleasing to see the way in which the candidates responded to the material as they clearly engaged with the contexts. Most candidates were able to respond to all of the elements of the examination and to make meaningful contributions throughout. The aim of the examination is to give candidates the opportunity to showcase what they have learned about the subject and the skills that they have developed. There were some excellent examples of work produced by candidates, this is pleasing to see given the disruption that has taken place throughout the last couple of years.

The areas of the programme and examination which appeared difficult for the candidates

A number of candidates struggled with graphical analysis and the interpretation of relationships. Candidates seemed to have problems understanding how to justify an inverse relationship between two variables graphically. Many could only state that as one variable increases the other variable decreases. However, proving it mathematically through logical argumentation with numerical evidence was quite difficult for many candidates. Hence, some candidates had trouble evaluating the evidence provided by data sets. Many candidates did not recognize that a slope has units or don't know how to determine those units. In addition to this, the more fundamental skills of plotting points on a graph and reading data from a graph was seemingly challenging for a number of candidates. This was evident in question 4 where they had to plot a point and draw the line of best fit. It was also evident in question 1, where a pair of points was required to calculate the distance using data from the speed-time graph. Many candidates just used one data point or read the data from 2 points incorrectly.

When structuring their essay in response to question 8, relatively few candidates explained the technical challenges of planning a crewed mission to Mars using their scientific knowledge and understanding. Many candidates wrote extended sections in which political and economic discussions were presented but they wrote relatively little about the many physical

considerations and challenges involved. Only the very strongest candidates could reference relevant challenges and relate these to ideas about forces, gravitational fields, waves and energy.

The mixing of ice cubes in salt water and regular water revealed a number of misconceptions about heat, convection, condensation, density, and buoyancy. A number of candidates struggled with applying the principles of convection currents (or lack of convection currents) due to the change of density of the fluid.

Some misconceptions were evident with the application of Newton's first law to question 1. Some candidates seemed to believe that the motion of the train is always in the direction of the net force applied to it. Many candidates did not explain that when the train was moving at a constant velocity, the net force is zero. Thus, the drag force and thrust force are equal.

Many candidates struggled with correctly explaining why high voltage can reduce power loss. There were all sorts of misconceptions such as assuming the resistance would increase when the voltage across the power line was increased. Candidates struggled to make the link between an increased in voltage leading to a decreased current, meaning fewer electrons dissipating less energy.

The areas of the programme and examination in which candidates appeared well prepared

Most candidates were familiar with the units for common quantities such as force and time. The conversion of units, such as seconds into minutes, was also quite well done.

The calculation of average values from a set of repeated measurements was well done.

The manipulation of animations to collect data was also well done.

Most candidates could perform calculations using kinematics equations (such as speed=distance/time) and normal mathematical routines such as finding the average of three values.

The majority of candidates displayed a clear structural understanding of how to plan a scientific investigation given a relevant context for an investigation. They were able to choose and classify the key variables (independent, dependent and control variables) and to outline a procedure for the collection of relevant data. Question 6(d) was generally well done; it was clear that candidates have been taught explicitly how to answer this kind of question and there was a logical structure present in the majority of candidate responses. However, this was noted to be less consistent with the French language responses, in particular when outlining variables.

The majority of candidates could organise and present data in a table although there were some common errors with rounding and the presentation of inconsistent decimal places in a column.

The extended response question relating to putting humans on Mars was well done and there were some very interesting and insightful responses in evidence. A large number of candidates were able to discuss implications by drawing on their knowledge and wider studies and to explore both sides of an argument before presenting a concluding appraisal.

The strengths and weaknesses of the candidates in the treatment of individual questions

Question 1

Most candidates correctly identified the units of force. Those candidates who got it wrong typically mixed up the units of energy (joule) with force (newton). The majority of candidates could label the forces acting on the train using a free body diagram. However, a number of candidates had challenges relating the concept of equilibrium of forces to motion at a new speed. Very few were able to recognize that the drag force and thrust force are equal when moving at a constant velocity. Some candidates thought the newly redesigned train was simply more efficient but didn't recognize the air resistance was smaller. In 1(d), most candidates understood what to do in order to calculate the distance travelled by using the speed-time graph, either by calculating the area under the graph or by utilising an appropriate kinematic equation. However, a number of candidates simply performed a speed x time calculation, which in this case is inaccurate due to the train undergoing deceleration in the tunnel. Two data points were required to obtain an accurate answer. 1(e) was generally well done.

Question 2

It seemed that a number of candidates found this question challenging. Some candidates were unable to respond to elements of the question and there were quite a few misconceptions evident in candidate responses. 2(a) was designed to be quite a low-demand question but a number of candidates did not know that 100% efficient means that the power input is equal to the power output. In 2(b), candidates were able to calculate the voltage of the output using the data in the table and a P=IV calculation, alternatively they were able to do a calculation using the numbers of turns shown in the diagram; both answers were accepted. The transformer equation and the power equation are given in the equations list as part of the on-screen examination package. It would be helpful to remind candidates to write down the relevant equations before the substitution phase in order to get partial credit in the case that they make errors with the calculations later on. A number of candidates performed a calculation that assumed that the primary coil and the secondary coil had equal resistances. This is a misconception which is based on flawed logic; therefore it received no credit. More candidates were able to perform the calculations required to answer 2(c). Question 2(d) was conceptually quite difficult for the candidates to grasp. Despite the earlier questions relating to efficiency and to power being conserved, a number of candidates stated that the high voltage of electricity meant that more power was delivered. Not many candidates could explain that the current is reduced when the voltage is increased and that this reduced energy loss in the wires.

Question 3

Candidates will have been taught about the processes of thermal energy transfer but a number of candidates encountered challenges in applying their knowledge to everyday observations that are best explained by these processes. The investigation that was the focus of this question could be performed quite easily in a home kitchen but this proved to be a surprisingly difficult question for the candidates to answer. 3(a) was well answered with few exceptions, showing that most candidates knew the definitions of radiation, convection, and conduction. For 3(b), a number of candidates chose A or B instead of D showing that some candidates didn't clearly understand that heat is always transferred from a high to a low temperature region. For 3(c), a number of candidates could identify the correct process of condensation but this was not as many as was expected. This point in the question showed that not all of the candidates were following the logic of what was happening during the investigation. Parts (d) and (e) were not particularly well done on the whole and a lot of misconceptions were evident. Some answers tried to explain the observations using diffusion, specific heat capacity and chemical reactions. It is possible that the context, which involved a convection current being set-up by a cold fluid falling to be replaced by warmer fluid at the bottom of the beaker, was not consistent with other convection currents that have been studied, which usually involve fluids being heated from below. Some candidates got close to the answer by discussing the difference in density of salt water and pure water but failed to connect this with the water at the top being colder.

Question 4

Most candidates could state an appropriate research question [4(a)] and could identify the tubes required to address this research question [4(b)]. 4(c) was not meant to be a challenging question but not all candidates explicitly stated that material and diameter needed to be controlled in order to have a fair test. Also, the identification of length as the independent variable needed to be made explicitly. The majority of the responses for 4(d) did not go into the required depth to be awarded 3 marks. Candidates were required to perform a test for inverse proportionality using a pair of points but many candidates just stated that an increased length corresponds to a decreased frequency without any analysis. 4(e) was generally well done but there were a small number of errors with rounding. The last parts of the question related to graphing and graphical analysis. There were some errors with the placement of the data point in 4(f); candidates should always check the scale of the axes carefully.

Question 5

This was generally well done by the majority of the candidates but not all candidates were able to suggest valid extensions to the investigation being studied. For question 5(a), candidates often forgot to convert grams to kilograms. They should be reminded that the kilogram, not the gram, is the base unit in science. A number of candidates didn't write down the equation that they selected to use in their calculation. This would be worth 1 mark, even if the answer was incorrect. The variables in 5(b) were generally well done but some candidates should be more specific when stating these. For example, if 'material of wire' is stated as a control variable for 1 mark, then 'type of wire' is not good enough to be awarded a second mark – the control

variables suggested should be clearly distinct. Question 5(c) was usually well answered with candidates usually getting 2-3 marks. The most common error was with rounding measurements. Candidates should not add zeroes to the measurements they are given. If some measurements have more decimal places than others these should be removed through rounding to give consistent columns of data. Questions 5(e) and 5(f) led to a number of candidates losing marks as they simply gave the same variables as the original experiment they should have been extending. The question clearly asked for a different investigation and as such these responses received no credit. A few candidates didn't realise that the hanging mass of the weights is the same as the tension in the string. Candidates need to be reminded that changing the equipment for an investigation does not constitute a new investigation. Also, they should not state the names of equipment as control variables. Some candidates chose to list the distance between the string and electronic tuner being a control variable but this was not given any credit as it would have no influence on frequency. Lastly, candidates should be reminded that when explaining a hypothesis they should use scientific reasoning. Simply stating the expected relationship between the variables does not constitute an explanation.

Question 6

This question was generally well answered by candidates, the extended planning question in particular showed a clear and logical structure. 6(a) was generally well answered, showing that candidates understood the purpose of taking 3 trials (and not just to take an average). However, a number of candidates said that it would improve the accuracy without further justification. This is not necessarily true. So, it is important to discuss the concepts of reliability and anomalies in relation to data collection. 6(b) was well answered by most candidates. Only a few made rounding errors by quoting the average to a number of decimal places instead of rounding to the nearest whole number which was consistent with the data. Question 6(c) was a bit more challenging and candidates had to analyse the pattern in the data to get the correct answer. Some candidates didn't quite recognize the pattern. A common incorrect answer was 103 dB. For question 6(d), which was an extended planning question, candidates showed that that on the whole they have been well prepared for these kinds of questions. Some weaker candidates confused frequency with the loudness of a buzzer. Also, some weaker responses did not include a method for the collection of data but this was clearly stated as a requirement of the question. Only the very strongest responses gave clear justification for the control variables – *eg* distance should be controlled as an increased distance would decrease the sound intensity level measured. And relatively few responses contained a hypothesis that was explained using relevant scientific knowledge. The requirement for the collection of sufficient data seems clear to most candidates.

Question 7

Question 7 was relatively challenging for a number of candidates. For 7(a), it was clear that most candidates were familiar with the heliocentric and geocentric models but not many candidates correctly explained why the observed motion of Mars as viewed from Earth was not consistent with the geocentric model. A number of candidates simply stated the details of the heliocentric model without addressing the requirements of the question or referencing the

animation. 7(b) was answered successfully by the majority of candidates. Usually, candidates could calculate the time using the speed = distance/time formula. A number of candidates could also convert the value to minutes although a few candidates made errors here and didn't round the final answer to the nearest minute. 7(c) was conceptually quite challenging for candidates as they had to consider the movement of Earth and Mars as well as the time taken for the rocket to travel. It should be seen as logical that a launch date would be proposed so that the travel time between the two planets would be minimised but some candidates had a different argument.

Question 8

There were a large number of interesting and insightful responses to this question and candidates clearly engaged with the context. Many candidates showed great insight into the economic and political implications of attempting to put humans on Mars. It was nice to read some of the historical context that was given by candidates who talked about the political background to the space race of the 20th Century and how the landscape had changed since then. Some candidates gave too much focus to the activities of private companies, whereas the question asked specifically about governments. A large number of responses didn't go far enough into the exploration of the technical challenges of the journey to Mars. In this element it was expected that the candidates would reference relevant Physics principles in talking about the challenges of the journey. Only a small number of responses did this very well. Weaker candidates failed to give more details beyond what was given in the information of the question. Some candidates just repeated facts and responses like this will receive very little credit. Other candidates used information from question 9 and thought the question was asking about people living on Mars rather than the journey to and from Mars when discussing the technical challenges.

Question 9

This was an interesting question that really stretched candidates to apply their own understanding of the challenges of living on Mars. There were two parts to the question: the challenges and the solutions to the problems. A number of candidates failed to describe the effects of low temperature, high radiation, and low gravity. They simply talked about the solutions. Other candidates described the effects without proposing solutions. Candidates should be reminded that the solutions they propose should be grounded in scientific principles and not science fiction. Some candidates talked about making artificial gravity without giving any details. A few candidates had some misconceptions about the reduced gravitational field strength on Mars by saying that everything would just float away. Other candidates talked about having heating and air conditioning like we have on Earth without really understanding the extreme cold temperatures that exist on Mars and how that would be a threat to life.

Recommendations and guidance for the teaching of future candidates

Candidates should be given opportunities to practice laboratory work in an open inquiry format. Inquiry-based laboratory investigations are integral to the MYP Physics program. Inquiry-based investigations allow candidates to apply scientific practices as they identify the questions they want to answer, design experiments to test hypotheses, conduct investigations, collect and analyse data, and communicate their results.

A hypothesis does not have to be correct to receive credit in the examination, but there should be an attempt to explain the hypothesis using scientific reasoning. Without an attempted explanation, the hypothesis is incomplete and would be considered to be a prediction.

When calculating a slope or area under the curve for a graph, remind candidates to use two data points (that are at least ⅔ length apart on the line of best fit). The acquisition of accurate data requires candidates to be familiar with the scale being used so they should pay attention to this. Remind candidates to show their work for part marks and to include appropriate units whenever a calculation is performed. Sometimes candidates lose marks because they don't show any work (such as an appropriate equation before substitution) so they don't receive any partial credit for an incorrect final answer.

When answering questions regarding how variable x affects variable y, tell candidates to use terms such as increases, decreases or remains the same. If they say simply “it changes”, this response will rarely receive credit. A response that references a specific mathematical relationship between x and y variables, such as direct or inverse proportionality, is even better.

Remind candidates to read questions carefully and answer the question that was asked. For example in question 8, a number of candidates used information from question 9 to answer it. However, the question wasn’t about living on Mars but about the journey to Mars. Candidates should be made familiar with the MYP command terms as they have precise meanings and are used to communicate specific requirements.

Teach candidates to use scientific terms correctly. They should know the difference between reliable, precise and accurate data. Some candidates seem to use these terms interchangeably without recognizing their specific meanings.