International Baccalaureate
Baccalauréat International
Bachillerato Internacional

PHYSICS

Overall grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 16	17 - 29	30 - 41	42 - 51	52 - 60	61 - 70	71 - 100

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 14	15 - 27	28 - 38	39 - 48	49 - 57	58 - 67	68 - 100

Internal assessment

Component grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 8	9 - 16	17 - 22	23 - 27	28 - 33	34 - 38	39 - 48

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 8	9 - 16	17 - 22	23 - 27	28 - 33	34 - 38	39 - 48

Comments specific to November 2009

Some teachers are allowing students to use two independent variables in their design investigations. Teachers should not let this happen. See the section “Guidance and authenticity” page 19 in the Physics Course Guide.

Some schools are still submitting evidence for their group 4 projects. Evidence is no longer required; only a PS mark, and the date and time for the project on the 4/PSOW.

Some teachers are assessing CE on standard classroom investigations, and this makes it difficult for students to find weaknesses and suggest improvements. Ohms law for a resistor or the simple pendulum, for example, are too well established to give room for students to achieve their best on CE.

Some students are turning IA investigations into a research project something like a miniature extended essay. Evidence of textbook theory and Internet information tends to make the assessment of Design investigations inappropriate. When the student is given the theory and an equation, designing an investigation and assessing it are often inappropriate. For example, several students investigated the relationship of the resistance of a wire to the length of the wire after studying series and parallel circuits. Such an investigation leaves little room for a truly open-ended investigation.

Many teachers are still asking students to write a hypothesis with their design assessment. Although not inappropriate, requiring a hypothesis often restricts the topic of investigation. A truly open-ended research question can be one where the student has no idea of the result. This type of investigation is then wide open for assessment under CE and the students can achieve their best. It is not impossible, however, to suggest a hypothesis in aspect 1 of CE. Hypothesis is not removed from physics, it is just too limiting when assessing student work. Students are not penalized for this but it is suggested that a wider range of appropriate investigation is possible by not requiring a hypothesis in assessed work.

Many schools are assessing all three criteria in one investigation. This works well, and gives the student many opportunities to achieve their best. Some schools, however, are only assessing two complete labs, and students should have three or four chances (marked work) at each criterion over the two-year course.

A large number of students have been drawing graphs by hand. This is not penalized but the IB encourages the use of ICT, and by using graphing software students can easily explore a variety of functional relationships in their data.

Most teachers marked consistently and appropriately. Some of the best students were marked severely by their teachers and in such cases the moderator raised marks. In other cases, teachers were too lenient in marking and moderators reduced marks slightly. In most cases, the teacher's marks were appropriate, consistent and at the correct level, and here no moderation was done.

There were, unfortunately, a number of downward moderations due to the teacher assessing inappropriate investigations. This is unfair to the student. Please read your feedback forms to find out if any of your investigations were inappropriate.

The range and suitability of the work submitted

The transition to the revised IA structure went very well. The majority of schools understood the requirements. Teachers continue to demonstrate an improvement in selecting appropriate labs for each criterion. Problems occurred, however, when teachers assigned two clearly defined variables for design, or assessed design when determining a specific quantity, such as gravity. The rule of thumb is to look for a function or relationship between two variables. Students need to make decisions and different students should come up with slightly different investigations given the same teacher prompt. Although hypothesis is no longer required under the planning of an investigation, some teachers are asking students for this. It should be noted that assessment does not address hypothesis. However, some physical interpretation may occur in CE, and hypothesis might appear here, but it is not required.

Data collection and presentation was done well. Occasionally teachers awarded full marks when units and uncertainties were absent, and of course these are required. Occasionally teachers would mark DCP when no graph was drawn.

Under DCP students are expected to process data by graphing. Teachers need to access investigations that are appropriate to the criteria.

The majority of schools offered a diverse practical program with investigations ranging from low tech to the use of sophisticated equipment. Most schools covered a wide range of topics, but more than a few schools failed to provide students with practical experience on both options studied. Teachers are reminded that investigations on physics topics not in the syllabus can be appropriate for learning experimental skills. The majority of schools completed the required hours. There were a few suspicious cases, however, where (for example) a school claimed 4 hours of IA time for a thought experiment on gravity, and another school claimed 5 hours investigating Hooke's law. Moderators often question such claims.

DCP and CE are usually inappropriate for assessment when students work with simulations, such as radioactive decay using dice or a computer model of Snell's law. These are learning exercises but they are not appropriate for assessment. Standard textbook labs with standard classroom equipment are not usually appropriate for assessment under CE.

Candidate performance against each criterion

Design

The majority of schools are assigning appropriate design topics. The key to success under the design criterion is the teacher's prompt. It needs to direct a student toward a research question without doing the student's thinking for them. Variables need operational definitions. If a student says she will measure the size of a crater, then she needs to explain what the size is. Is it the width measured from rim tops, the depth measured from the level surface or just what? The terms independent, dependent and controlled variables need to be clearly understood by students.

Controlling variables was properly addressed in most cases but there were occasion where students needed to be more specific. Just saying, "I will measure the period of a pendulum" is not sufficient. Attention to detail is expected for a complete. Similarly, sufficient data requires an appreciation of the scope and range of values, as well as repeated measurements. Most students are addressing these issues. Occasionally teachers over-mark this aspect. Teachers are reminded that moderators only know what is written out in the student's report.

Data Collection and Processing

This criterion tends to earn the highest marks for students. The expectations are clearly spelled out in the IA descriptors. Teachers are reminded that the expectations for the treatment of errors, uncertainties and graph gradients are detailed in the Physics Course Guide syllabus. There were only a few instances where students were told what to graph. Teachers are reminded to read the clarifications in the Physics Course Guide under DCP for what is expected from the student. A few students drew free-hand graphs. The IB expects students to use graph paper or preferably graphing software.

A complete in DCP aspect 3 requires students to present processed data appropriately (without mistakes or omissions). The clarifications in the course guide state that a relevant graph will have appropriate scales, axes with units, properly plotted data points, a best-fit line, and that error bars and minimum and maximum gradients will be used to determine the uncertainty in the gradient. Section 1.2 of the syllabus gives the details of what is expected.

Students may use more sophisticated methods of error analysis, such as standard deviation and other statistical methods, but the course guide explains the minimum level of error and uncertainty appreciation.

It is expected when assessment is made under DCP that students construct graphs. However, there may be exceptions to this, where DCP is appropriate for assessment but a graph is not appropriate. For example, perhaps students are using time-lapse photographs of a moon orbiting Jupiter and gather data to determine the gravitational constant, G. There would be raw and processed data, and raw and processed uncertainties. The final value of G would have an uncertainty range (and it would be compared to the accepted value) and yet no graph would be relevant. Such an investigation could earn a complete under DCP aspect 3.

There may be other examples of assessed work under DCP without graphs. In such cases the moderator must assess the type of investigation and determine if a high school student could have and should have constructed a graph. If a graph would have been relevant but one was not used, then a complete cannot be awarded to DCP aspect 3.

For example, in a simple pendulum experiment to determine g, a student may have processed data and found an average for gravity. Without a graph a possible systematic error (perhaps of wrongly determined length of the pendulum) would not have been revealed. In an example of a Boyle’s law experiment, the dead space in the pressure gauge would not be revealed without graphing the data. Or, when measuring the speed of sound with an open-ended resonance tube, only appropriate graphing reveals the end-effect. In all these cases the moderator could not accept a complete for DCP aspect 3 without a graph.

Finally, there is a type of experiment that may or may not be appropriate for graphing. In an experiment to measure the specific heat capacity of water, a student may process data and uncertainties correctly and then calculate a numerical value of c. However, it may be relevant to construct a graph in this experiment because of an experimental error in the heating process. A graph of temperature against time (for constant electrical power source) would reveal a non-linear temperature increase with time, hence revealing an important experimental error. In this case a graph is relevant and hence required for the work to earn a complete under DCP aspect 3.

When a student’s investigation is assessed for Design as well as DCP then a graph is most certainly required. This is because, under Design, students should be looking for a function or relationship between two variables. These variables would then be appropriately graphed.

The conclusion from the above observations is that in the majority of investigations, a graph is expected. Teachers are advised that when assessing DCP graphs should be involved. However, there are exceptions. The moderator needs to determine whether or not the intention of the physics syllabus statements about error analysis have been achieved without a graph and whether or not the student’s investigation should have involved a graph.

Conclusion and Evaluation

CE aspect 1 achievement level 3 requires students to ‘justify’ their reasonable interpretation of the data. Going beyond a partial requires something more than summarizing the graph. Perhaps some physical theory, or at least some physical interpretation or meaning is required here. Students should ask themselves what the gradient of the graph means, what (if anything) a systematic shift in the graph might mean, and what the scatter of data points might mean. Aspect 1 is probability the most difficult of all IA to achieve a complete. Students often confuse the words “linear” with “proportional” when talking about a graph’s line.

Recommendations for the teaching of future candidates

- Teachers should make sure that all assessed work is appropriate for assessment by the relevant criterion. This may sound obvious but there are numerous cases where students were denied possible marks because the teacher assessed inappropriate tasks. Remember that only a fraction of all the hours attributed on the 4/PSOW form need to be assessed.
- Although only the two highest marks per criterion are used to establish a student's IA grade, students need a number of opportunities at assessed work in order to improve and do their best. Some schools are marking only two sets of work, and this is unfair to the student.
- Teacher's are reminded to use only the most recent version of the 4/PSOW form (the current one has spaces for the moderator's and senior moderator's marks), and to include the 4/IA cover form. The PS mark is established with the group 4 projects but no evidence of the project is required for moderation. Remember to send only the lab samples that are to be moderated. Some schools are sending entire portfolios. Finally, students and teachers must sign and date the 4/PSOW form.
- There is ample evidence of the use of ICT. The IB encourages this. The majority of students are word-processing their lab reports, and many schools are using graphing software. The other ICT requirements are being met.
- Teachers are reminded of the teacher support material (TSM) that is available on the Online Curriculum Centre (OCC) physics pages. See Assessment, Internal Assessment, and then TSM. The material here covers issues of design, errors and uncertainties, MS and it includes 10 student labs that are marked with moderator comments.
- Teachers are allowed to respond to student questions as they do their experimental work and as they write up their reports. However, teachers must not grade a draft of a lab report, and teachers should respond to questions only by directing students routes of inquiry (and not answering questions directly). In assessing student work using IA criteria, teachers should only mark and annotate the final draft. See the section of the Physics Course Guide called "Guidance and authenticity" for more detail.
- It is essential when work is to be assessed that students work on their own. There cannot be a set of common data or identical results if the work is to be assessed.

Further comments

This last section contains the advice that is given to physics IA moderators. Overall, moderators normally keep the teacher's marks, but occasionally they raise or lower marks. If the teachers have applied the criteria to appropriate tasks in good faith then the moderation system should support them. Moderators are not here to apply their own pet theories and practices as teachers, but to ensure that the schools are using the criteria within acceptable bounds according to the official descriptors. In other words, moderators are **looking for the systematic error beyond the random error in the application of the aspects of the criteria**. The following advice is given to the moderators.

When moderators mark down.

Design

The moderator will mark down when the teacher gives a clearly defined research question and/or the independent **and** controlled variables. The teacher may give the student the dependent variable (as long as there is a variety of independent variables for the student to identify). Giving the student the general aim of the investigation is fine if the students have significantly modified the teacher prompt or question (e.g. made it more precise, defined the variables). The moderator will mark down when a method sheet is given which the student follows without any modification *or* **all** students are using identical methods. Standard laboratory investigations are not appropriate for assessment under Design.

Data Collection and Processing

The moderator will mark down when a photocopied table is provided with headings and units that are just filled in by students. If the student has not recorded uncertainties in any quantitative data then the maximum given by the moderator is 'partial' for first aspect. If the student has been *repeatedly inconsistent* in the use of significant digits when recording data then the most a moderator an award is 'partial' for first aspect. In physics data is always quantitative. Drawing the field lines around a magnet does not constitute DCP.

The moderator will mark down when a graph with axes already labelled is provided (or students have been told which variables to plot) or students follow structured questions in order to carry out data processing. For assessment under DCP aspect 3, students are expected to construct graphs. For a complete, the data points on the graph should include uncertainty bars, and the uncertainty in the best-straight line gradient needs to be calculated. The method for this is often the minimum and maximum gradients using the first and last data points.

Conclusion and Evaluation

If the teacher provides structured questions to prompt students through the discussion, conclusion and criticism then, depending on how focused the teacher's questions are and on the quality of students' response the maximum award is *partial* for each aspect the student has been guided through. The moderator judges purely on the students input. The difference between a partial and a complete for CE aspect 1 involves the justification of their interpretation of the experimental results. This is a difficult task, and it can involve physical theory.

When moderators do not mark down

In the following cases the moderator will support the teacher's stance, as they are aware of their own expectations of the students.

Design

Moderators do not mark down when the independent and controlled variables have been clearly identified in procedure but are not given as a separate list (we mark the whole report and there is no obligation to write up according to the aspect headings). Moderators do not mark down when there is a list of variables and it is clearly apparent from the procedure which is independent and which are controlled.

Moderators do not mark down when similar (but not word for word identical) procedures are given for a narrow task. The moderator will make a comment though on the poor suitability of a task on 4/IAF form. Moderators do not only mark the equipment list, they give credit for equipment clearly identified in a stepwise procedure. Remember moderators look at the whole report. Moderators do not insist on +/- precision of apparatus to be given in the apparatus list. This has never been specified to teachers and the concept of recording uncertainties is dealt with in DCP. Moderators do not downgrade a teacher’s mark if something as routine as safety glasses or lab coats are not listed. Some teachers consider it vital to list them each time and some teachers consider them such an integral part of all lab work that they go without saying. Moderators support the teacher’s stance here.

Data Collection and Processing

In a comprehensive data collection exercise possibly with several tables of data the student has been inconsistent with significant digits for just one data point or missed units out of one column heading, then the moderator will not mark this minor error down. If the moderator feels the student has demonstrated that they were paying attention to these points and made one careless slip then the moderator can still support maximum marks under the ‘complete not meaning perfection’ rule. This is an important principle since good students responding in full to an extended task unfairly get penalized more often than students addressing a simplistic exercise. The student is not marked down if they have not included any qualitative observation(s) and the moderator cannot think of any that would have been obviously relevant. The moderator does not mark down if there is no table title when it is obvious what the data in the table refers to. Often students do all the hard work for DCP and then lose a mark from the class teacher because they did not title the table. Except for extended investigations it is normally self-evident what the table refers to.

The expectation for the treatment of errors and uncertainties in physics is described in the Course Guide and the TSM. Both standard level and higher-level students are assessed on the same syllabus content and the same standard of performance. All raw data is expected to include units and uncertainties. The least count of any scale or the least significant digit in any measurement is an indication of the minimum uncertainty. Students may make statements about the manufacture’s claim of accuracy, but this is not required. When raw data is processed, uncertainties need to be processed (see the Course Guide, syllabus section 1.2.11)

Students can estimate uncertainties in compound measurements (± half the range), and they can make educated guesses about uncertainties in the method of measurement. If uncertainties are small enough to be ignored, the candidate should note this fact.

Minimum and maximum gradients should be drawn on linear graphs using uncertainty bars (using the first and last data points) for only one quantity. This simplified method becomes obscured when both graph quantities contain uncertainty bars. Other uncertainty analysis is expected when graphs are non-linear.

If the student has clearly attempted to consider or propagate uncertainties then moderators support the teacher’s award even if they may feel that the student could have made a more sophisticated effort. If propagation is demonstrated in part of the lab then full credit can be awarded even if error analysis is not carried through in every detail (as long as the student has demonstrated an appreciation of uncertainty then they can earn a complete).

Moderators **do not** punish a teacher or student if the protocol is not the one that you teach i.e. top pan balance uncertainties have been given as +/- 0.01g when you may feel that if we consider the tare weighing then it should be doubled. Moderation is not the time or place to establish a favoured IB protocol.

Conclusion and Evaluation

Moderators often apply the principle of 'complete' not meaning perfect. For example, if the student has identified the most sensible sources of systematic error then the moderator can support a teacher's award even if the moderator can identify one more. Moderators are a bit more critical in the third aspect that the modifications are actually relating to the cited sources of error. If the moderator feels a task was too simple to truly meet the spirit of the criteria, then comments on the 4IAF as to the unsuitability of the task giving full justifications will be provided in feedback but the moderator will not necessarily downgrade the student. Yes, this does mean that students could get high DCP marks for some quite brief work on limited data but, if they have fulfilled the aspect's requirements within this small range, then the moderator will support the teacher's marks.

The most challenging aspect of CE is the differentiation between a partial and a complete under aspect 1: "States a conclusion, with justification, based on a reasonable interpretation of the data." A justification may be a mathematical analysis of the results, one that includes an appreciation the limits of the data range, but it might also be an analysis that includes some physical meaning or theory, even an hypothesis (though a hypothesis is not required). It is difficult to earn a complete in CE (aspect 1) because serious and thoughtful comments are required, something beyond "the data reveal a linear and proportional relationship". See the last paragraph in the Conclusion and Evaluation comments in section B above.

General comments on the written papers

IB multiple choice physics papers are designed to have, in the main, questions testing knowledge of facts, concepts and terminology and the application of the aforementioned. These Assessment objectives are specified in the Guide. It should be noted that multiple-choice items enable definitions and laws to be tested without full recall, but requiring understanding of the underlying concepts.

Although the questions may involve simple calculations, calculations can be assessed more appropriately in questions on Papers 2 and 3. Calculators are therefore neither needed nor allowed for Paper 1.

In Papers 2 and 3, candidates are sometimes asked to write short paragraphs so that their understanding of topics may be assessed. It is clear that, from many answers, candidates have been trained to give definitions and to perform calculations, but have little understanding of the underlying physics. It is this lack of understanding that prevents candidates from achieving the higher grades.

Candidates should be encouraged to give precise definitions for physical quantities. Definitions given partly or totally in terms of units are not acceptable.

Paper one

Component grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 10	11 - 15	16 - 21	22 - 25	26 - 28	29 - 32	33 - 40

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 10	11 - 14	15 - 16	17 - 19	20 - 21	22 - 30

General comments

A proportion of questions are common to the SL and HL papers, with the additional questions in HL providing further syllabus coverage.

Only a small percentage of the teachers or Centres taking the examination returned G2's. At both HL and SL there were responses from only 8 Centres. Consequently, general opinions are difficult to assess since those sending G2's are likely to be those who feel strongly in some way about the Papers. The replies indicated that the November 2009 papers were well received. A majority of the teachers who commented on the Papers felt that they contained questions of an appropriate level. With only one exception teachers thought that the Papers gave satisfactory or good coverage of the syllabus with clear wording and presentation.

It should be stressed that Grade Award meetings always start with consideration of the G2's. These alert the examiners to potential problems with the papers and give them an indication as to how the papers compare to the previous year. It is disappointing that more schools do not return these as a matter of course.

Statistical analysis

The overall performance of candidates and the performance on individual questions are illustrated in the statistical analysis of responses. These data are given in the grids below.

The numbers in the columns A-D and Blank are the numbers of candidates choosing the labelled option or leaving the answer blank. The question key (correct option) is indicated by being shaded. The *difficulty index* (perhaps better called facility index) is the percentage of candidates that gave the correct response (the key). A high index thus indicates an easy question. The *discrimination index* is a measure of how well the question discriminated between the candidates of different abilities. In general, a higher discrimination index indicates that a greater proportion of the more able candidates correctly identified the key compared with the weaker candidates. This may not, however, be the case where the difficulty index is either high or low.

HL paper 1 item analysis

Question	A	B	C	D	Blank	Difficulty Index	Discrimination Index
1	19	271*	193	264	5	36.04	0.30
2	140	11	586*	14	1	77.93	0.25
3	50	245	39	417*	1	55.45	0.39
4	192	116	148	294*	2	39.10	0.33
5	388*	233	22	107	2	51.60	0.56
6	41	685*	1	23	2	91.09	0.17
7	275*	56	93	325	3	36.57	0.31
8	28	642*	58	22	2	85.37	0.24
9	371*	113	177	88	3	49.34	0.24
10	25	156	510*	59	2	67.82	0.45
11	649*	38	30	33	2	86.30	0.29
12	47	619*	36	49	1	82.31	0.28
13	609*	42	83	17	1	80.98	0.38
14	38	44	521*	148	1	69.28	0.27
15	144	286*	232	86	4	38.03	0.29
16	24	75	511*	141	1	67.95	0.48
17	24	68	82	577*	1	76.73	0.32
18	105	14	552*	79	2	73.40	0.46
19	356*	250	46	97	3	47.34	0.59
20	279*	173	153	146	1	37.10	0.44
21	21	5	177*	548	1	23.54	0.26
22	196	419*	85	50	2	55.72	0.60
23	15	37	185	514*	1	68.35	0.59
24	81	58	513*	99	1	68.22	0.30
25	163	155	103	329*	2	43.75	0.47
26	62	49	540*	99	2	71.81	0.26
27	32	14	682*	23	1	90.69	0.22
28	69	537*	119	24	3	71.41	0.56
29	54	17	49	631*	1	83.91	0.23
30	625*	20	75	31	1	83.11	0.38
31	96	101	525*	26	4	69.81	0.46
32	418*	104	105	120	5	55.59	0.58
33	350*	206	157	37	2	46.54	0.66
34	39	436*	89	187	1	57.98	0.53
35	49	86	142	472*	3	62.77	0.66
36	182	85	63	420*	2	55.85	0.79
37	243	132	318*	55	4	42.29	0.40
38	50	653*	12	36	1	86.84	0.25
39	103	575*	63	8	3	76.46	0.41
40	342*	36	47	324	3	45.48	0.62

Number of candidates: 752

SL paper 1 item analysis

Question	A	B	C	D	Blank	Difficulty Index	Discrimination Index
1	40	202*	244	278	1	26.41	0.31
2	34	578*	129	23	1	75.56	0.36
3	144*	84	407	130		18.82	0.18
4	196	18	519*	30	2	67.84	0.31
5	232	157	160	214*	2	27.97	0.34
6	414*	125	58	166	2	54.12	0.42
7	76	624*	22	43		81.57	0.29
8	106	128	249*	280	2	32.55	0.33
9	25	684*	26	28	2	89.41	0.23
10	37	167	461*	98	2	60.26	0.43
11	585*	75	60	45		76.47	0.44
12	38	306	55	366*		47.84	0.53
13	63	65	454*	183		59.35	0.56
14	43	94	101	527*		68.89	0.35
15	101	32	535*	97		69.93	0.26
16	120	194	168	270*	13	35.29	0.54
17	233	321*	124	87		41.96	0.52
18	229	161	128	247*		32.29	0.47
19	33	82	249	393*	8	51.37	0.75
20	601*	93	33	38		78.56	0.37
21	245*	208	94	217	1	32.03	0.33
22	40	33	644*	48		84.18	0.35
23	49	480*	179	55	2	62.75	0.53
24	15	81	166	503*		65.75	0.37
25	64	274*	141	284	2	35.82	0.40
26	114	607*	22	21	1	79.35	0.30
27	80	109	183	377*	16	49.28	0.65
28	55	595*	25	87	3	77.78	0.30
29	258	96	74	331*	6	43.27	0.70
30	323	64	336*	29	13	43.92	0.40

Number of candidates: 765

Comments on the analysis

Difficulty

The difficulty index varies from about 24% in HL and 19% in SL (relatively ‘difficult’ questions) to about 91% in HL and 89% in SL (relatively ‘easy’ questions). The majority of items were in the range 30% to 70%. Thus, the Papers provided ample opportunity for all candidates to gain some credit and, at the same time, gave an adequate spread of marks.

Discrimination

All questions had a positive value for the discrimination index. Ideally, the index should be greater than about 0.2. This was achieved in a large majority of questions. However, a low discrimination index may not result from an unreliable question. It could indicate a common misconception amongst candidates or a question with a high difficulty index. At both levels, about 50% of the coefficients of discrimination were above 0.40.

‘Blank’ response

In the SL Paper, the number of blank responses tended to increase towards the end of the test. This may indicate that candidates did not have sufficient time to complete their responses, despite a lack of comments from teachers to this effect. Even so, this does not provide an explanation for ‘blanks’ earlier in the Papers as there were in HL. Candidates should be reminded that there is no penalty for an incorrect response. Therefore, if the correct response is not known, then an educated guess should be made. In general, some of the ‘distractors’ should be capable of elimination, thus reducing the element of guesswork.

Comments on selected questions

Candidate performance on the individual questions is provided in the statistical tables above, along with the values of the indices. For most questions, this alone will provide sufficient feedback information when looking at a specific question. Therefore comment will be given only on selected questions, i.e. those that illustrate a particular issue or where a problem can be identified.

SL and HL common questions

SL Question 5 and HL Question 4

At both levels a considerable number of candidates were mislead by A, suggesting that they were used to marking in *components* of forces directly on force diagrams. This practice only leads to confusion.

HL Questions

Question 7

Most students incorrectly chose D. If ‘potential gradient’ had been automatically equated with ‘field strength’ in students’ minds, then its vector nature may have been more transparent.

Questions 14 and 15.

The responses to both these questions showed that students had not been carefully introduced to the physics of longitudinal waves and the meaning of their typical *displacement-distance* graph.

Question 19

Students need to be aware of the factor of 1.22 used for circular lenses.

Question 20

This was a difficult question with evidence that many students were guessing. Students need to be able to describe the *plane of polarisation* of a light wave and relate it to reflection as well as the effect of optically active solutions.

Question 21

The vast majority of students incorrectly chose D as their answer. Kinetic energy gained is equal to potential energy lost. Furthermore, kinetic energy can only be positive, so, whether q is negative or positive, the only correct response can be C.

Question 30

The diagram was not drawn strictly to scale, but this did not confuse the majority of the students.

Question 37

The question asked for the *fractional* increase in volume, a unitless number. The distracter A gives the absolute rise in the volume.

SL questions

Question 3

This is a common mind-teaser that very few students were able to answer correctly. At its heart is a clear understanding of the concept of *acceleration*. As the two balls have the same acceleration they will have a fixed velocity difference between them, meaning that the distance between them increases with time.

Question 8

Most students understood that the gradient of the graph referred to a force, yet they failed to go one step further and identify the direction of the force. The gradient is negative, which means that it is in the opposite direction to the momentum of the ball. It can, therefore, only refer to the force by the wall on the ball.

Question 12

It was disappointing to see the number of students who incorrectly selected B. This would suggest that they were applying the formula without consideration to the situation. As $\mu > 1$, and as $\theta_4 > \theta_1$, the correct answer must be D. It may be advisable to teach Snell's Law by referring to 'big' and 'small' angles rather than to angles of incidence and refraction.

Recommendations and guidance for the teaching of future candidates

Candidates should make an attempt at every item. Where they cannot provide the correct response, then they should always choose that option which, to them, appears to be the most likely. It should be emphasised that an incorrect response does not give rise to a mark deduction.

The stem should be read carefully. It appears that some candidates do not read the whole stem but rather, having ascertained the general meaning, they move on to the possible responses. Multiple choice items are kept as short as is possible. Consequently, all wording is significant and important. In particular students were frequently confused by questions involving direction or possible + and – answers. These need to be thought through carefully where both alternatives are given.

Students should develop the habit of looking at the units of the responses where appropriate. This can frequently result in the elimination of incorrect responses.

The areas of the syllabus that were poorly done were force diagrams and electric circuits.

In general the results were in line with those of previous years and indicated that the students are comfortable with the new syllabus.

Paper two

Component grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 12	13 - 24	25 - 32	33 - 42	43 - 52	53 - 62	63 - 95

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 12	13 - 17	18 - 22	23 - 26	27 - 31	32 - 50

This was the first presentation of the new syllabus in a November session and careful scrutiny of G2 forms was undertaken. It was a pity that only 9 centres at HL (7 at SL) out of about 150 entering candidates sent in forms as the feedback from a larger number would have been helpful. However, the overwhelming majority felt that the papers were of an appropriate standard with no centre suggesting that any difficulty had risen. All centres felt that the syllabus coverage, clarity of wording and presentation of both papers were satisfactory or good. The mean mark rose by about 5 marks compared to November 2008 with the standard deviation remaining about the same. In general, the rise appeared to be confined to the average candidates with the weaker and stronger candidates faring about the same as in previous years.

General comments

Many candidates were able to apply themselves well to these papers which proved to be accessible throughout both compulsory and optional sections. Candidates should take more account of the mark structure when constructing their answers. There was some evidence that candidates do not plan which option questions to answer in a preliminary and sensible way; more candidates than usual began option questions only to abandon them a few marks in.

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

The examining team identified the following areas: -

- inability to answer ‘show that’ questions with a logical presentation of the arguments
- poor quality of Sankey diagrams
- discussion of social and environmental issues
- de Broglie hypothesis
- energy losses in electrical ac transmission

- relationship in diffraction between slit width and appearance of pattern
- thermal equilibrium
- identification of energy changes in gas processes
- electrical theory

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

It was pleasing to see the following skills demonstrated: -

- mechanics
- simple harmonic motion
- energy conversions in topic 8 areas

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

There were many common questions between SL and HL. The comments below are arranged in the order that the questions appeared in HL.

Section A

A1 [HL and SL] Data analysis question

General comment

The context for this question was straightforward and pitched at an appropriate level for SL and HL.

a) Almost all candidates were able to complete the error bars correctly.

b) This was poorly done; there were two marks available but few candidates bothered to consider more than one point. Those who discussed the straight line aspect of proportionality rarely mentioned the issue of error bars and the need for the line to lie within them. Candidates who considered the necessity for the line to go through the origin fared better.

c) In (i) powers of ten errors (misreads from the graph axis) were common. About two-thirds of candidates were able to manipulate the fractional errors in (ii) to arrive at a correct answer.

d) This was comparatively poorly done, power of ten errors were common even from those who had read correctly in (c)(i). Many simply took points on the line (acceptable) or actual data off the line (not acceptable). Many candidates failed to quote a unit for their answer.

A2 [HL and SL] Thermal energy transfer

a) (i) Thermal capacity was well defined except by those who confused it with specific heat capacity.

(ii) Thermal equilibrium was poorly outlined. Many simply suggested that the temperature of the copper and the flame were the same; examiners would wish to see a treatment where the dynamic rate of energy flow is the same in both objects.

b) (i) Many candidates obtained full credit here but solutions were marred by inabilities to cope with Kelvin to Celsius conversions (not in fact needed) and by significant figure penalties.

(ii) This was poorly done. Many simply quoted ‘losses to the environment’ as the explanation for the copper temperature being greater than the calculated estimate. Examiners felt that this was a stock response and that candidates should have considered more carefully the transfer of the copper or the possible energy loss from the cup.

A3 [HL and SL] Gravitational and electrical fields

a) Whilst many were able to *identify* the symbols, far too many simply wrote down the conventional symbols that appear in texts and the data book. This did not attract full marks. Likewise, the true meaning of *s* was often not clear with candidates simply writing down ‘distance’. Examiners needed to know the distance under consideration.

b) The calculation of the ratio was only reasonably well done with some candidates being unable to identify the correct physical constants to substitute with many power of ten or arithmetical errors.

A4 [HL] Diffraction

a) (i) The diffraction intensity pattern was usually crudely drawn with intensity proportions incorrect (subsidiary maxima too high) and with scant regard for the relative widths of the intensity maxima. Candidates need to pay more attention to a sketch that is to be worth a 3 mark maximum.

(ii) The effect on reducing the slit width was also poorly done. Far too many thought that reducing the width increases the energy arriving at the receiver. Ideas about the relationship between aperture and spread of maxima were confused and candidates unable to translate the relationship that they spotted in the data book into physical meaning.

b) Whilst most could explain that the food cooked evenly as a result of its rotation in the microwave, few could relate the behavior of the standing wave nodes and antinodes to the effective heating of the food.

A5 [HL only] Forces

a) Although many had the correct (and simple) approach to calculating the weight of the ball, there were far too many significant figure errors here.

b) (i) Better candidates realized that this part of the question needs to be addressed via an energy conservation approach. Others used an inappropriate equation of motion; the acceleration is not constant in this case.

(ii) About half of the candidature realized that there was a need to calculate the centripetal force in this case. But only about half of these recognized the importance of *adding* this value to the known weight to calculate the total tension.

c) (i) Too many quote the quantity for the area under the force-time graph as ‘momentum’ rather than ‘change in momentum’.

(ii) The determination of the maximum force of the ball on the wall was poor. There were many failures to include the factor of 2 to allow for the area of the triangle. Many attempted to use an $F=ma$ approach without success.

Section B

B1

Whole question [HL] Generation of electrical energy and global warming & Part 1 [SL] Pumped-storage power station

a) (i) This was an easy three marks for many candidates.

(ii) Many were able to arrive at the correct solution. There were a number of ways to arrive at this.

b) (i) Almost all candidates could calculate the overall efficiency

(ii) Unlike the May 2009 examination, Sankey diagrams were poor. Some candidates clearly did not understand what is required in such a diagram (clear labelling, energy losses shown in the correct order, width of sectors proportional to energy loss/output, etc). Other diagrams were so poorly drawn, free-hand and without care, that examiners were loathe to award full marks. This was a particularly poor area of the paper even from able candidates

c) **Not SL**

(i) Explanations here were very poor and incomplete. Some could get no farther than a standard quotation of Faraday’s law.

(ii) This standard calculation was well done.

(iii) Almost all candidates forgot that the coil has two sides and consequently omitted the factor of 2 in the final answer to gain only partial credit.

d) **SL (c)**

(i) Discussions of energy losses in transmission lines were fragmentary. Detail was rare with, commonly, a simple statement that the voltage is high. Other candidates simply discussed the physics of the transmission line and the need for materials with a low resistivity or (curiously) an insulating cover to the line.

e) **Not SL**

(i) Calculations were marred by inabilities to convert km to m in order to use the density values (or vice versa).

(ii) These power of ten problems carried through into the next part with many errors carried forward.

B1 Part 2 [SL only] Force and energy

a) (i) Almost all realised that the net force acting on the cyclist is zero.

(ii) This question was done very badly. There was little or no understanding of where the forces act and even less idea that the length of the vector should match the proportional size of the force. These basic ideas pervade the whole of physics and are clearly misunderstood by many.

(iii) Most seemed to gain one out of two marks. It was rare to see clear explanations of both the nature and size of the forces acting horizontally.

b) This very simple calculation was completed successfully by many.

c) (i) and (ii) were done well.

(iii) The explanation was poor with most candidates focussing either on the non-uniformity of the force or on the nature of the force itself.

B2

B2 Part 1 [HL only] B3 Part 1 [SL only] Nuclear fission and fusion

a) (i) It was good to see that many candidates have a good understanding of the meaning of binding energy.

(ii) Almost all candidates identified the maximum of the curve as being that of the most stable.

(iii) This was straightforward: candidates needed to state that the binding energy *per nucleon* was a maximum but most discussed only the binding energy and failed to gain credit.

b) (i) Many candidates who persevered at this calculation managed to arrive at a successful conclusion.

(ii) Again, most could state that 2 neutrons were emitted in the fission.

(iii) Weak candidates struggled here and were unable to use $E=mc^2$ with any facility. Other failures for stronger candidates were arithmetical errors or, surprisingly, failing to square c.

(iv) Most candidates gained whatever marks they accrued here through an accurate drawing of the fission process. Written descriptions were muddled and failed to focus on the particular reaction quoted in the question.

c) Discussions of the social and environmental benefits of fission failed to give real physics or gave erroneous physics. It seemed that candidates suddenly begin to lose all their understanding once they begin to write in broader terms.

B2 part 2 HL Charge-coupled devices

a) The condition for resolution on a CCD was in general well expressed.

b) (i) Most able candidates were able to show convincingly the length of a pixel side. However, given that this was a ‘show that’, explanations of the physics and mathematics involved were very poor.

(ii) The calculation of the potential difference across a pixel was not good. There was a misunderstanding of the true meaning of quantum efficiency and some candidates could not deal with the relationship between charge stored, potential difference and capacitance.

(iii) Most were able to understand the connection between pixel spacing and resolution.

c) Candidates were told to couch their discussions in terms of data storage, many failed to do so and lost marks accordingly. There was a widespread and erroneous belief that film has a poorer resolution than a digital medium; the present state of technology does not allow this for domestic use.

B3

B3 Part 1 [HL] and B2 Part 1 [SL] Simple harmonic motion

a) Weaker candidates were often not able to indicate the conditions required for simple harmonic motion.

b) (i) Most were able to state the amplitude of vibration.

(ii) The graphs were drawn adequately but there was a tendency for the time period to change along the time axis and this was marked down by examiners. At this level, sketches must be much more accurate.

(iii) There was a clear widespread failure to identify the time period. Often candidates marked just one point on the axis assuming the origin without marking it correctly. Best solutions featured a double-headed arrow showing very clearly the time period. Amplitude indications were much better, but even so some identified the peak-to-peak distance as the amplitude.

c) (i) Too many candidates attempted to use either equations of motion or the equation $c=f\lambda$ to determine the linear speed.

(ii) Again, inappropriate equations were used to determine the acceleration of the tuning fork tip.

d) **[HL only]** the sketch of the acceleration against time was well done by many, but predictably some drew the line 180° out of phase.

e) **[HL only]** (i) Damped motion was well described, usually in terms of amplitude decrease. Obviously, descriptions in terms of the displacement decreasing fail to score.

(ii) Air resistance or the emission of sound were frequently and correctly cited as a reason for the damping.

B3 Part 2 [HL only] Thermodynamics

a) Symbol identification was generally very poor. Few candidates gained three marks, there was rarely a consistent link between *Q* and *W* (in terms of energy gained by the gas and work done on the gas).

b) (i) Most recognised that the volume was constant in the process.

(ii) This explanation was poorly done. There was rarely a recognition that work has to be done by the gas against the atmosphere. It was rare for a candidate to acknowledge the link between temperature and average kinetic energy.

(iii) Calculations of the quantities were generally well done.

B4

B4 Part 1 [HL] B2 Part 2 [SL] Electric circuits

a) Many candidates gained 2 or 3 out of the 4 marks available. Failure points included the perennial inability to draw potential divider circuits and a lack of knowledge of the physical relationship between a voltmeter and the p.d. of the component that it is being used to measure.

b) About half the candidates drew the graph as a straight line through the origin rather than showing the change in properties with increasing filament temperature.

c) Most were able to calculate the current in the lamp.

d) About half the candidates were able to calculate the required radius of the filament with an appropriate use of the resistivity equation.

e) Explanations of both the calculations and the rationale behind the decision as to whether the lamps in parallel would light normally were generally weak. Many candidates could not cope with the fact that the lamps were in parallel. Examiners had real difficulty in understanding the thought processes that candidates were trying to express. Candidates must make clear both the physics of the situation and how it is being used.

B4 Part 2 [HL]

a) (i) There seemed to be a widespread failure to know or understand the details of the Davisson and Germer experiment. Descriptions of the observed phenomenon were poor and lacked detail.

(ii) About one-quarter of candidates choosing this option were able to tackle this calculation; this was disappointing. Most could not even begin.

b) Many explanations failed to focus on the question and gave rambling accounts of de Broglie's hypothesis but did not attempt to link it effectively to the model specified in the question.

B3 part 2 [SL]

a) (i) Most candidates did not distinguish between the greenhouse effect and its enhanced effect. So descriptions were general and failed to focus on the physics of enhancement.

(ii) The question asked candidates to consider effects other than that of enhanced global warming. Many did not understand the distinction and described man-made effects rather than those that occur naturally.

b) (i) Calculations were marred by inabilities to convert km to m in order to use the density values (or vice versa).

(ii) These power of ten problems carried through into the next part too with many errors carried forward.

c) Whilst it is possible that some did not understand what was meant by an oceanic ice sheet, explanations and statements of the effect produced by melting the sheet were poor and unsubstantiated. Candidates clearly did not understand the factors of importance in this effect.

Recommendations and guidance for the teaching of future candidates

There is a real lack of precision in written answers, especially in those requiring an explanation. Arguments that show a logical progression are few. Candidates should be encouraged to be able to define the terms that they are using and to define symbols if they are using them. The command term is of great importance for the candidate in answering a question; they seem to be unaware of the nuances. In particular, in a 'show that' question, candidates must be encouraged to lay their work out in a logical and clear way. A simple quotation of the answer (usually given anyway) together with a jumble of algebra and numbers will not do for full credit.

Paper three

Component grade boundaries

Higher level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 14	15 - 21	22 - 26	27 - 30	31 - 35	36 - 60

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 3	4 - 7	8 - 12	13 - 16	17 - 19	20 - 23	24 - 40

General comments

Many candidates found it hard to perform well on these papers even though marks were accessible to those candidates who found difficulty with the more conceptual aspects of the Options.

There was no evidence that candidates were short of time to complete their work.

The feedback from teachers on the G2 forms for SL and HL is summarized below. It should be borne in mind that this summary is based on a very small number of returns. In view of the small number of returns, the conclusion is that the majority of schools were happy with the papers.

Standard Level

- The majority of centres (90%) found the paper to be of a similar standard to last year. Clearly this judgement is more difficult to make than in previous years as this is the first November session examining the new syllabus.
- All centres found the level of difficulty appropriate.
- In terms of syllabus coverage, 56% judged it good and 44% satisfactory. All agreed that the clarity of wording was appropriate (67% good, 33% satisfactory) and all also approved the presentation of the paper (67% good, 33% satisfactory).
- There was a clearly uneven choice of options, with options A (Sight and wave phenomena), Option B (Quantum physics and nuclear physics), E (Astrophysics) and G (Electromagnetic waves) being the most popular ones. Few centres opted for C (Digital technology), D (Relativity and particle physics) or F (Communications).

Higher Level

Again it should be borne in mind that there were very few G2 returns, less than for SL.

- 33% of the centres found the HL Paper to be of similar standard to last year, 17% found the paper a little more difficult and 33% finding it much more difficult. Despite this comparison, the level of difficulty was judged to be appropriate by 86% with only 14% finding it too difficult.
- In terms of syllabus coverage, clarity of wording and presentations no centre judged the presentation of the paper to be poor. 57% found the coverage and clarity of wording to be good, with the rest judging it satisfactory
- There was a clear cut difference among the choice of options. The different combinations of Option E (Astrophysics), G (Electromagnetic waves), H (Relativity) and I (Medical physics) were chosen by a significant number of centres. Options F (Communications) and J (Particle physics) being chosen in similar proportions by a few centres only.

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

The areas identified by the examination team as being difficult were as follows:

- Explaining concepts in Physics in a way that demonstrates understanding (e.g. polarization, evidence for atomic energy levels, simultaneity, Olber’s paradox, and chromatic aberration.)
- Calculations involving ratios.
- Cosmic microwave background radiation
- Schwarzschild radius and spacetime.
- Operational amplifiers.
- Diffraction grating
- Relativistic energy and momentum

- Providing sufficient depth and detail in questions with a mark allocation of more than one mark. This was particularly true in those questions involving the action verbs "explain", "outline" and "describe".
- Lack of precision in definitions and correct use of scientific terminology.

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

The majority of candidates were able to complete the more straightforward calculations successfully.

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

SL only

Option A – Sight and wave phenomena

A1 The human eye

This question was generally well-answered. However answers to (a)(ii) and (b) often lacked sufficient detail to score full marks. For example omitting to mention that rods and cones convert light into electrical signals and also that accommodation involves the actually focussing of the image.

A2 Doppler Effect

A common error was to not to note the increased spacing shift and/or draw all to the right of line C.

A3 Optical resolution

Candidates often calculated the angle correctly and then got lost. Answers to (b) often showed the lack of precision mentioned above e.g. "use a bigger lens".

A4 Polarizing filters and sources

This was not done well. Many candidates got hopelessly confused in (a) and in (b) either knew about polarimetry or did not.

Option B – Quantum physics and nuclear physics

B1 Quantum Physics and electrons.

(a) (i) was usually well-answered but many candidates failed to note the command term "explain" in (ii) and just stated that there is no change.

In (b)(i) it was clear that many candidates had seen this type of solution before and were able to handle the calculation well. Others attempted to use $c = f\lambda$. In part (ii) many candidates were aware of electron scattering by crystals.

Part (c) was not done well. As alluded to above, candidates generally have difficulty with extended responses and are not good at writing scientific explanations. Some candidates completely missed the point of question (i) and just talked about the hydrogen atom. Often in (ii) little reference was actually made to the line spectra.

B2 Radioactive decay

This was often done well. However, the calculation did defeat a significant number of candidates. A common error was to multiply the original activity by the decay constant when using the activity equation.

Option C – Digital technology

C1 Storing information on a CD

This question was usually very well answered in parts (a) and (b) but (c) was nearly always answered poorly. Very few candidates really demonstrated a familiarity with this section of the syllabus usually showing no skills to solve problems involving circuits incorporating operational amplifiers.

C2 Charge-coupled devices (CCD)

Many candidates seemed to know what capacitance is, even when some did not necessarily score the mark as they tended to offer descriptive answers. Several candidates were able to handle calculations in (b) successfully but quite a few got lost in part (ii).

Option D – Relativity and particle physics

D1 Special Relativity

Most candidates understood what is meant by an inertial frame of reference but whereas most recognised that Aibhe measured the proper length the (incorrect) reason often given was because she is in the reference frame that is at rest.

The two calculations were often correct but (d) was often poorly answered. The concept of simultaneity is not well understood by candidates. Most answers would seem to indicate that candidates are not aware that the time at which an event takes place is measured by a clock at rest at the place where the event takes place. Also they do not appear to appreciate that the events take place in all reference frames. Another misconception is that simultaneity somehow has something to do with observers seeing the light from the events. The situation in this question is complicated somewhat by the fact that the Aibhe is not at the midpoint between the insects. Nonetheless if the clocks at the two places where the insects land record identical times for the landings then, no matter where Aibhe is in relation to the insects, she will always be able to calculate that the clocks recorded identical times. Although Euan will agree that the events are simultaneous for her, they will not, because of the relative motion and time dilation, be identical for him. Clearly all that answers were expected to show for an outline command term is that candidates understood what is meant by the time of an event and, based on the postulates of relativity, what effect relative motion between observers has on the recorded times.

D2 Fermions and bosons

Apart from one or two good answers to parts (a) and (b), the few candidates attempting this option showed little or no understanding of the topics addressed by the questions.

SL and HL combined

Option E – Astrophysics

E1 Becrux and Cepheid variables

A significant number of candidates did not appreciate the apparent magnitude scale is a relative scale and/or that it applies to an Earth observer. However, the concept of absolute magnitude was well-known.

Of the calculations in (b), (i) was generally done better than (ii). The ratios in (ii), as in previous years, posed problems for many candidates. Several candidates in both (i) and (ii) assumed the answer and did the problems by substitution, which is an acceptable method.

Although in the markscheme a degree of latitude was given for the region of the Cepheids, many positions marked were very inaccurate. The reason for their variation in luminosity was generally well known but few appreciated that the apparent brightness as well as period needs to be measured in order to compute galactic distances.

E1 [HL only]

Quite a few candidates had difficulty with the manipulation of the power coefficient in (c) but the fates of the two stars were well known.

Evolutionary paths drawn for Becrux were often somewhat strange completely missing the red super giant region.

E2 Cosmology

Although the question in (a) specifically asked for a quantitative explanation of Olber’s paradox, a significant number of candidates attempted a qualitative explanation. The maximum allowed for this in the markscheme was 2 marks.

E2 [SL only]

Although many candidates appreciated that the resolution of the paradox lies in the fact that the Big Bang theory predicts a non-uniform, finite and expanding universe, several just stated that the universe is expanding with no further detail

E2 [HL only]

Answers to (b) (i) often lacked precision and so did not score well. The idea of a universe at an initially high temperature was not often mentioned. Some candidates just gave a description of CMB and so did not answer the question.

The main error in the calculation in (ii) was to use the wrong value of wavelength. Also the units, as always, caused several candidates problems.

Option F – Communications

F1 Modulation

The concepts of AM and FM would appear to be well understood except when it came to the FM calculations in (d) which were rarely done correctly and often not attempted.

F2 Digital signals

The calculation on bit-rate, a(i), was not done well even though the answer was given.

Correct answers to (a)(ii) that did not assume the starting point as $t = 0$ were given full credit. It was not often appreciated that increasing the sampling frequency means that smaller increments of voltage will be measured.

The problem in (c) was often completed correctly but also left unanswered by several candidates.

F2 [HL only] [SL C3]

The question on operational amplifiers was nearly always answered poorly. Very few candidates really demonstrated a familiarity with this section of the syllabus usually showing no skills to solve problems involving circuits incorporating operational amplifiers.

F3 [HL only] Mobile phone systems

Candidates were usually very familiar with the moral and environmental issues that the use of mobile phones produce. There was a range of very imaginative answers, particularly in respect of the moral issues e.g. bullying and cheating in exams

Option G – Electromagnetic waves

G1 Electromagnetic spectrum

Surprisingly few candidates scored the full three marks for this question. Quite often one of the components was answered incorrectly and more often than not this was a wrongly stated order of magnitude for a gamma ray frequency.

In (b)(ii) quite a few candidates recognised the health hazards of using gamma-rays but a common misconception was that this was due to the rays being radioactive.

G2 Chromatic aberration and a lens

Part (a) was often answered correctly but sometimes the foci were the wrong way round. Explanations of chromatic aberration in (b) were often poor with no reference ever being made to the image. Most candidates just stated in words what they had drawn in (a).

Part (c) was usually correct and the calculations in (d) were also often done correctly.

G3 Two source interference.

Part (a) was often done well with the exception of (iii) where imprecise answers lost marks. For example, it is not sufficient to say that the pattern becomes more intense and/or sharper. What is required is a reference to the principal maxima.

The problem on the diffraction grating in (b) was generally not done well. Many candidates did not attempt it or started from the double slit formula. A common error for those who used the diffraction grating formula was to omit the central maximum and/or to take into account that maxima are formed either side of the central maximum

G4 [HL only] Thin-film interference

Many candidates seemed to be unfamiliar with this topic. An error by those candidates who seemed to know about this topic was to forget the factor ½ in the problem in (b) and so only scored one of the two marks available.

G5 [HL only] X-rays

This was often done well but some candidates confused the production of electrons with the photoelectric effect. The given diagram could have been more accurate but there was no evidence that this disadvantaged candidates. Some candidates also forgot to convert joule to eV in (b) but still made their answer to be 0.050 nm, the value stated in the question!

HL only

Option H – Relativity

H1 [SL D1] Special relativity

Most candidates understood what is meant by an inertial frame of reference but whereas most recognised that Aibhe measured the proper length the (incorrect) reason often given was because she is in the reference frame that is a rest.

The two calculations were often correct but (d) and (e) were often poorly answered. The concept of simultaneity is not well understood by candidates. Most answers would seem to indicate that candidates are not aware that the time at which an event takes place is measured by a clock at rest at the place where the event takes place. Also they do not appear to appreciate that the events take place in all reference frames. Another misconception is that simultaneity somehow has something to do with observers seeing the light from the events. The situation in this question is complicated somewhat by the fact that the Aibhe is not at the midpoint between the insects. Nonetheless if the clocks at the two places where the insects land record identical times for the landings then, no matter where Aibhe is in relation to the insects, she will always be able to calculate that the clocks recorded identical times. Although Euan will agree that the events are simultaneous for her they will not, because of the relative motion and time dilation, be identical for him. Clearly all that candidates answers where expected to show for an outline command term is that they understood what is meant by the time of an event and what effect the relative motion between observers has on the recorded times.

[HL only]

In (e) a common misconception was that time goes slower for the muons because they are moving very fast. Few answers referred to proper time or proper length and often failed to identify the relevant reference frame of either the muons or of the Earth observer. Having said this, it has to be acknowledged that several candidates demonstrated a clear understanding of the situation.

H2 Relativistic energy and momentum

Many candidates answered part (a) correctly but all too often this was the only part of the question other than some correct answers to (b)(i) that was answered well. It is clear that candidates, as in similar questions in past papers, have difficulty coping with units given in combinations of eV and powers of c.

H3 Spacetime and black holes

Answers to (a) and to (b) were often imprecise e.g. “spacetime consists of three space dimensions and one time dimension”. In (b) the actual radius was rarely defined with something along the lines “the point where even light cannot escape” often given as an answer. Part (c) was usually answered well.

Option I – Medical physics

I1 Hearing

A reference to the increase in the force was often omitted in (a). Answers to (b)(i) tended to treat the command term “suggest as “state” e.g. “the response of the ear is logarithmic”. The rest of the question was usually done well,

I2 X-rays and laser light

Some graphs missed the first point in (a). Answers to (b)(i) did not refer to half-value thickness even though the question specifically asked for this. Full credit was given in (b)(ii) for candidates who calculated correctly the ratio of the changes in intensity. The concept of pulse oximetry was completely unfamiliar to candidates from some centres.

I3 Radio isotopes

Parts (a) and (b) were often answered well but (c) caused difficulty for some candidates. Few recognised that a ¼ of the sample is left after 4 days and that the physical activity has dropped by ½ in this time. Many candidates went by the (acceptable) route of calculating the effective half-life but often this was as far as they got.

Option J – Particle physics

J1 [SL D2] Fermions and bosons

Apart from one or two good answers to parts (a) and (b), the few candidates attempting this option showed little or no understanding of the topics addressed by the questions.

J2 Particle accelerators

Parts (b) and (c) were the usually the best answered parts of this question. Few candidates knew the reason why accelerated protons must have high energy to create other particles in collision with other protons. Nor were they familiar with the advantages and disadvantages of particle production from collision with protons and anti-protons moving in opposite directions.

J3 Quarks

Few candidates showed any familiarity with the concepts addressed by this question.

Recommendations and guidance for the teaching of future candidates

Recommendations from the examination team included the following ideas:

- Candidates should be given time to practice answering questions from past examination papers.
- Candidates should be provided the list of command terms as specified in the syllabus and their significance should be explained to them. It is clear that many candidates do not recognise the difference between, for example, a “state” and an “explain”.
- The method must be able to be followed easily by the examiner in a “show that” or “determine” type of question.
- All diagrams should be clearly labelled and any straight lines should be drawn with a ruler.
- Enough teaching time should be given in order to cover all topics in a particular Option.
- Candidates should read all of a question before starting to answer as many questions are of a structured nature.
- Candidates should be taught precise and unambiguous definitions.
- The teaching of the Options should not be left until the end of the course nor should candidates be left to study an Option on their own without supervision.