May 2016 subject reports

Astronomy

Overall grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-17	18 - 27	28 - 38	39 - 49	50 - 61	62 - 72	73 - 100

Standard level internal assessment

Component grade boundaries

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

The range and suitability of the work submitted

From May 2017 the Internal Assessment framework changes fundamentally and teachers must avail themselves of the guidance given in the Subject Guide and Physics Teacher support Material.

Advice that arises from the current session but can be projected on to the new framework is as follows.

- Encourage students to choose a research question that has a degree of challenge, is of interest to them and one where they do not know at the outset what the outcome will be.
- A good research question will probably try to determine a trend or relationship.
- Students should include some background theory to set the context of their investigation.
- With a ten hour time allocation to facilitate meaningful enquiry it is expected that students will collect more data than is currently the case in Design assessments.

- It is sensible for students to always be encouraged to make a statement related to the safety, environmental or ethical impact of their study.
- Encourage students to reflect on data while carrying out the research so that they can actively make the decision to modify the procedure or collect more data if needed. This is a good indicator of true engagement and candidates can record such decisions being made.
- When analysing their data students should show appreciation of the impact of measurement uncertainties. This could be evidenced through the propagation of errors using a sensible protocol through a calculation, the drawing of a graph with appropriate best fit line and quite possibly the inclusion of error bars and always the appropriate use of significant figures. Since the Individual Investigations will take many different forms the teacher will have to decide what constitutes the appropriate treatment of uncertainties applicable to that research.
- If the research includes the analysis of secondary data students should still show consideration the associated uncertainty.
- When concluding, students should draw a conclusion and discuss its methodological validity but should also compare it to expected outcomes (if any) based on accepted theory.
- If the outcome is quantitative then the comparison to a literature value, calculation of percentage error and discussion of the impact of systematic and random errors is still the expectation.
- In addition to possible modifications students should also reflect on possible extensions to their research.
- The Communication criterion will introduce new requirements. The students' designed procedures should include sufficient detail for the reader to be able to reproduce the experiment in principle.
- Although there is a requirement for more data and more reported detail, ideally the report should not exceed 12 pages. This means that students have to be intelligently concise and the current trend for hugely repetitious use of cut and paste for calculations or procedural details and the inclusion of pages of data-logged data should be avoided.
- There should be an increased focus on the proper referencing of sources used for background theory, procedural instructions or literature vales. This is a hugely important consideration that has to be stressed clearly to the students.
- Do not encourage the students to write up reports using the criterion titles as report sections. In particular Personal Engagement is a criterion to be assessed across the whole report and is not an introductory section.

- Written feedback or annotations on the student's work as to how the marks were awarded is of great value to moderators as they try to support a sensible interpretation of the assessment criteria.

This May 2016 session, the majority of work submitted was entirely suitable and showed a wide range of different approaches, which is excellent practice, since it allows students to show their skills in at least a subset, even if some types of investigation do not suit them.

However, for a small number of schools, the work submitted did not allow the criteria to be adequately assessed. It was particularly worrying that even in these cases, high marks were sometimes awarded to students for demonstrating skills that the format of the investigation made it difficult or impossible for them to demonstrate. As an example of this, some investigations consisted of simple worksheets, with students answering fixed questions, or completing partially pre-drawn graphs. In these circumstances, students are not able to show design or interpretation skills and so should receive no marks.

In all these circumstances, it would improve things considerably if schools would consider the criteria for assessment, and the descriptors, before deciding on the investigations they are going to give to the students. In particular the need to identify controlled and independent variables was sometimes missed, and some data was provided to students that did not allow any form of error analysis.

Candidate performance against each criterion

Design (D)

For the majority of schools, design aspects were well covered and students did well.

The exceptions were when the investigations submitted were inappropriate and did not allow students sufficient scope to demonstrate significant design skills. In many of these cases it was likely that the schools had not sufficiently understood the nature of the assessment, as not only were the investigations unsuitable, but the marks awarded could not be justified by the work submitted. It is important that investigations that are going to be assessed for Design criteria are sufficiently broad and open-ended to allow the students to make their own decisions.

Data Collection and Presentation (DCP)

In most cases data collection and presentation was good. Data tables were well presented and had sufficient information for each column (units and so on) and any exceptions were identified by teachers and feedback given to students. Graphs were also generally good with suitable use of error bars.

However, again, some of the investigations provided too much support for the students to show their own skills. Examples included providing tables with column headings already filled in, or graphs with axes pre-labelled.

Some investigations also involved data (for example from online sources) that did not include any error estimates. Under these circumstances, students cannot demonstrate any ability to manipulate or utilise errors and uncertainties, and so cannot be awarded credit for doing so. Such investigations should not be used to assess DCP components.

Conclusion and Evaluation (CE)

Although there was again some excellent work submitted for CE criteria, this was perhaps the weakest area.

Many conclusions were perhaps rather simplistic, and did not always follow on from the data, but were instead based on prior knowledge of pre-conceived assumptions (i.e. they were the conclusions that the students expected, not what they actually got). It may help for teachers to stress the importance of referring to the results and analysis to justify any conclusions.

There were also some slightly frustrating occasions where the experiment had gone very well, and had been very well designed, with the result that there were in fact very few significant improvements that could be suggested.

ICT coverage

The use of ICT was very good, with students making use of data manipulation and display software (e.g. spreadsheets), searching online databases, and using digital data gathering equipment. Use of specifically astronomical ICT was less common (e.g. computer controlled telescopes or astronomical simulations) but used well on occasion. In future, schools may wish to consider using online sources of observational data (e.g. robotic telescopes or online data archives) to make observational investigation more tractable, and get round the problems of night-time teaching.

The Group 4 Project

Other than (in some cases) the title, no information was provided about Group 4 projects, so this cannot be commented upon. From May 2017, candidates will have the obligation a reflective statement about their project.

The areas of the programme in which candidates appear well prepared

Candidates were generally well prepared to design experiments and investigations in a scientifically useful way, with good consideration given to controlled and independent variables, and the range of data needed to draw sensible conclusions. Also, in general, consideration of errors on measurements was excellent and their use in justifying conclusions was also good.

Recommendations for the teaching of future candidates

- Make sure that all schools and teachers understand the criteria for assessment, and that investigations are suitable for the criteria
- Make sure that the students are aware of the criteria that they are going to be assessed against and encourage them to re-read the criteria before submitting any work
- Where possible, investigations that include the collection or analysis of observations from telescopes should be considered. The use of online data archives and telescopes may make this easier.

Recommendations for IB procedures, instructions and forms

Clerical procedure

- Overall clerical procedures went well and the work submitted by schools was easy to follow.
- However, in some cases the 4/IA form or list of students was not included, which not only slows down the process of assessment, but also makes it more likely that any work that is accidentally not included will not be noticed. **This 4/IA form will no longer be needed in 2017 as candidates' work will be uploaded.**
- There was also a wide range in the level of information provided about the justification for marks awarded by teachers. For several schools, this was exemplary, with excellent feedback to students, and detailed mark breakdowns (including "complete", "partial" and "not at all" information as appropriate) together with notes describing the motivation behind marking choices. This is very useful as it not only means that any possible clerical errors can be easily identified, but it also ensures that any discrepancy between the marks awarded by the teacher and the examiner can be easily understood. However, for some submitted work, there was no mark breakdown or teacher comments and feedback.
- Some schools are sending photocopies of the student's work. Usually these are of good quality but graphs and diagrams that use colour can be confusing. It is much

better if originals are sent and a photocopy kept back.

Further comments

There was a lot of good work, with some schools showing a commendable range of different types of investigation. However, there were some schools where the investigations were rather narrow and did not really give the scope for students to showcase a wide range of relevant skills.

Of particular concern, there were a number of pieces of work submitted where the level of guidance given to the students was too high, or where the latitude given to students to design their own experiments, analyse data in a flexible way, or draw their own conclusions, was far too low.

This year also had a wider range of investigations that allowed students to develop observational skills, as well as experimental and data investigation ones. This sort of investigation is challenging as it often means working outside the classroom and at night, but since observations skills are essential to astronomy, this is a development that is very welcome and schools should be encouraged to continue the trend.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 9	10 - 12	13 - 15	16 - 21	22 - 24	25 - 30

General comments

None.

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

- Conversion between different kinds of units
- Commenting on the significance of the results of calculations.
- Some important terminology (e.g. “active galaxy”, “planetary differentiation”)

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

Calculations using standard astronomical formulae

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

Question 1

Calculations using standard astronomical formulae

Question 2

Those who knew what flux density was did well on this question.

Question 3

Answers were often too imprecise (e.g. “nuclear fusion”), although a significant number identified the proton-proton chain successfully and several also clearly knew the details of the reaction chain (although this was not required for the question).

Question 4

Most students identified retrograde motion as important, but several students did not appear to have read the question properly, and so gave answers that were not to do with the observed motion in the night sky.

Question 5

Although most students knew what a terrestrial planet was, only a smaller fraction were able to describe planetary differentiation.

Question 6

Although most students were able to identify and apply the correct equation, too many did not take the final step of using “the appropriate number of significant figures”, leading to unnecessary loss of marks.

Question 7

Answered well with only a small number of incorrect answers.

Question 8

Calculations using standard astronomical formulae

Question 9

M91 is clearly a *barred* spiral, and a number of students only said that the galaxy was a “spiral”. This may have been due to not reading the question properly.

Question 10

The majority of students correctly identified the two components, but a significant number identified the central black hole as a “basic part” of the galaxy. This may be due to a lack of appreciation of the significance of the black hole: it is impressive in its own right, but it is a negligible part of the galaxy (much less than 1% of the total mass).

Question 11

“Active Galaxy” is an important piece of astronomical terminology, but it was clear that many students had not come across it (or not sufficiently to remember it) leading to an assortment of guesses.

Question 12

Answered well with only a small number of incorrect answers.

Question 13

Answered well with only a small number of incorrect answers.

Question 14

Generally answered well, although a noticeable number of students seemed to confuse saddle-shaped with closed.

Question 15

Generally this was answered well, although too many marks were lost by students not converting from years to seconds.

Recommendations and guidance for the teaching of future candidates

None.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 9	10 - 14	15 - 20	21 - 27	28 - 32	33 - 39	40 - 60

General comments

It was good to see excellent work across the entire breadth of the syllabus content. The thought given to answers in Section B, where students were discussing an article containing some relatively unseen material, was often excellent and showed good thinking skills, not just memory work.

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

Sometimes the underlying physical concepts behind the astronomy were a little weak. In particular the appreciation of Black Body radiation was limited.

Where mistakes were made in calculations, leading to clearly nonsensical answers, very few students seemed aware or went back to check their working. Since simple mistakes in using calculators, or in forgetting to apply a power and so on, can be quite common, and students should be encouraged to always consider whether their answer is reasonable.

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

The use of standard astronomical equations and formula was excellent, and the nature of line spectra was well understood.

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

Section A

Question 1

Calculations were generally performed well (apart from the occasional error using calculators). However, a large number of students did not convert from ^{o}C to Kelvin when required.
The nature of black-body radiation was not well understood, and there was quite a lot of confusion about when line emission will and will not happen (and why it is different from black-

body radiation).

Question 2

Again, too many students failed to convert to appropriate units (in this case, mainly confusing km and m) leading to answers that were clearly incorrect. However, almost no students noted this, even when the question asked them to compare their result with a known one.

Question 3

Generally well answered, with most students performing the calculations well and most students aware of the effect and importance of the interstellar medium. Knowledge of the upper (i.e. longer distance) region of the distance ladder was weaker.

Question 4

Almost all students understood the nature of negative redshifts, and were able to calculate using redshift formulae. Some, however, were clearly confused between the measurement of the redshift from the wavelengths of spectral lines, and the use of redshift to determine (apparent) velocities and distances. Many students were also under the impression that the simple formula that is used for small redshifts ($v = zc$) was applicable for all redshifts, leading to a belief that there is a maximum redshift of 1.

Section B

Question 5

This was the more popular of the two questions in Section B, but not by a very large margin.

Generally students answered well, having clearly read the short article carefully and thought about it.

Where marks were lost, it was often due to incomplete or vague answers. For example, a number of students said that Jupiter's presence helped to form the asteroid belt, because of "its gravity" (or words to that effect). Not only is this too vague to be useful, students should have considered that this is not enough to justify a 3-mark question.

Other marks were again lost to failure to convert between units and simple calculator errors that were not noticed.

The discussion of the nature of the "bright spots" on Ceres gave rise to some excellent answers which showed independent thought.

Question 6

Again, the majority of students had clearly read the article carefully and had understood it well.

There were no particular parts of the question where answers were particularly strong or weak, but the magnitude calculations were generally well done, especially given that magnitudes are quite a difficult concept and quite different from most units in modern science.

Recommendations and guidance for the teaching of future candidates

Candidates should

- Think about all numerical answers and decide if they are sensible. If not, it may be a simple error that can be easily corrected.
- Carry out all calculations on a calculator more than once. If the answers disagree, it is another indication of a mistake.
- Be careful with units, and make sure that conversions are always done properly.
- Always give units for their numerical answers unless there is no unit (i.e. if the answer is dimensionless).
- Consider whether an answer is sufficiently detailed or precise. The number of marks awarded to an answer can be an indicator of the amount and level of information needed.

Teachers should also

- Ensure that core astronomical terminology is understood, and make it clear when words have particular, precise meanings within that terminology (e.g. the "active" in "active galaxy").
- Set practice questions which have a mixture of units to give students practice in converting between them (and in recognising the effects of failing to convert).
- Consider having exercises that involve "order-of-magnitude" estimations. This is not only useful in itself, but it will make it easier for students to spot when they have made a mistake in an exam question that leads to an unreasonable answer.
- Stress the importance of reading the question carefully.