Appendix 1: Instructions for candidates

This assessment applies to the project–report for Advanced Higher Physics.

This project–report is worth 30 marks out of the total of 130 marks. The Course will be graded A–D.

It assesses the following skills, knowledge and understanding:

- extending and applying knowledge of physics to new situations, interpreting and analysing information to solve more complex problems
- planning and designing physics experiments/investigations, using reference material to test a hypothesis or to illustrate particular effects
- recording systematic detailed observations and collecting data
- selecting information from a variety of sources and presenting detailed information appropriately in a variety of forms
- processing and analysing physics information/data (using calculations, significant figures and units, where appropriate)
- making reasoned predictions from a range of evidence/information
- drawing valid conclusions and giving explanations supported by evidence/justification
- critically evaluating experimental procedures by identifying sources of uncertainty, suggesting and implementing improvements
- drawing on knowledge and understanding of physics to make accurate statements, describe complex information, provide detailed explanations and integrate knowledge
- communicating physics findings/information fully and effectively
- analysing and evaluating scientific publications and media reports

Your assessor will let you know how the assessment will be carried out and any required conditions for doing it.

In this assessment you will carry out an in-depth investigation of a physics topic. The topic will be chosen by you. You must discuss the selection of possible topics with your assessor to ensure that time is not wasted on researching topics that are unsuitable. You will work individually to investigate/research the underlying physics of the topic. This is an open-ended task which may involve a significant part of the work being carried out without supervision.

The following table shows how the 30 marks are allocated to each of the categories against which the evidence will be assessed.

Category	Mark allocation
Abstract	1
Introduction	4
Procedures	7
Results (including uncertainties)	8
Discussion (conclusion(s) and evaluation)	8
Presentation	2
Total	**30**

In this assessment, you will have to produce a project–report. This report is submitted to SQA for external marking.

The same project–report cannot be submitted for more than one subject.

An overview of the Marking Instructions for the project–report is on page 17.

Prior to starting this assessment you should have started a physics investigation. This would normally be your *Investigating Physics* Unit. In this Unit, you are required to plan and carry out a physics investigation. You should keep a record of your work as this may form the basis of your project–report. This record should include details of your research, experiments and recorded data. Typically, this should consist of **three to four** related experiments.

Producing the project-report
The project–report submitted to SQA must have a logical structure and should be clear, concise and easy to read. It should be written in the past tense and the impersonal voice should be used. This is particularly important when describing the procedure(s) used.

The project–report should be between 2000 and 3000 words in length excluding the title page, contents page, tables, graphs, diagrams, calculations, references, acknowledgements and any appendices. The word count should be submitted with the project–report. If the word count exceeds the maximum by 10%, a penalty will be applied.

The project–report must include the following sections:

- Title page
- Contents page
- Abstract
- Introduction
- Procedures
- Results
- Discussion (conclusion(s)and evaluation)
- List of references

Title page
This page should have a title that clearly indicates the subject matter of the investigation. You might start out with a working title and then consider revising the wording of the title as the investigation nears completion. The title page must also have your name and candidate number and the name and number of the centre you attend.

Contents page
This page must list the sections within the project-report along with their corresponding page numbers for the purposes of cross-referencing. It is essential that all pages throughout the project–report are numbered.

Abstract (or Summary)
In your 'abstract' you must state the aim(s) and overall finding(s)/conclusion(s) of the investigation. The 'abstract' must be brief and should immediately follow the contents page and be separate from the 'introduction'. Although it appears early in the project–report, as the 'abstract' summarises the investigation, it may be one of the last things you write.

The overall finding(s) must be consistent with the conclusion(s) given in the 'discussion' and should relate to the aims.

Introduction
You must also include an account of the underlying physics that is relevant to the investigation. All terms used should be clearly defined. Simply stating equations is not sufficient. You must demonstrate a good understanding of the physics behind these equations. You might draw on a variety of sources of information when you are researching your chosen topic. In your account of the underlying physics, terms must be used accurately and ideas must be explained clearly. You should also include diagrams and relationships, as appropriate.

In this section you must include a concise account of the relevant background theory to the investigation at a level appropriate to Advanced Higher. Take care to use terms accurately and explain ideas clearly. The references you use as sources for the background theory must be cited in the text and listed at the end of the project–report.

Downloading directly from the internet or copying directly from books may suggest to the marker that you have not understood the physics involved and will be considered as plagiarism. It is always best to put things into your own words.

Procedures
This section must contain an account of the procedures carried out in your investigation. The procedures must be clearly described and in sufficient detail to allow the investigation to be repeated. This should include details of all apparatus, techniques, methods and materials used to obtain your data.

In broad terms, the procedures should allow the aim(s) to be achieved.

The experimental procedures that you use in your investigation must be at an appropriate level of demand for Advanced Higher Physics.

You must include labelled diagrams and/or descriptions of the apparatus that you used for experimental work. Photographs of assembled apparatus, with appropriate labelling, are acceptable. A satisfactory photograph showing clear detail should be labelled. Labelled circuit diagrams should be included where appropriate. There must be evidence that you have been involved in the planning of the investigation and have not simply followed a given set of instructions. The procedures should be written in the past tense and impersonal voice.

Bulleted/numbered points are only acceptable if statements are in sentences and are meaningful and coherent, ie must make sense if numbers or bullet points were to be removed, but must not be a list of instructions.

You must also give clear descriptions of how you used the apparatus to obtain your experimental results. You must give sufficient detail to allow your investigation to be repeated by another person. Range of reading and number of repetitions should also be included, where appropriate.

You should address such issues as range of procedures, control of variables, accuracy, precision, originality of approach and/or experimental techniques and degree of sophistication of experimental design and/or equipment.

Results (including uncertainties)
The results must be relevant to the aim(s) of your investigation.
In the 'results' section, you must provide all raw data as well as processed or derived data. Raw data are the readings you actually record in the course of the investigation.

Include all the measurements taken (not just the mean values) and show, perhaps by sample calculation, how they were analysed to produce a final result. Include units in tables and correctly use rounding to a given number of significant figures. Treatment of uncertainties should be shown in this section. You must quantify all (calibration, scale reading and random) uncertainties that have a bearing on the accuracy of your experimental work. A concise, logical and convenient presentation is essential.

Raw and processed data must be presented in a clear and concise manner with appropriate use of tables, graphs, diagrams and calculations. Tables must have appropriate headings and units must be specified.

Graphs must be supported with tables of raw and/or processed data, ie a graph on its own is not sufficient — the data from which it has been derived must also be presented. When drawing a graph, you must ensure that:

- scales are chosen so that the plotted points are widely spread
- each axis is labelled with the name of the quantity and the correct unit
- data are plotted accurately

- a best-fit straight line or curve is drawn — not 'join the dots'

Where Excel or other software packages are used to present graphs, it is important that axes are adapted to suit the data in order that the results are presented in the most appropriate way.

Calculations must be clearly structured. Where the same type of calculation is repeated for different raw data, then only one sample calculation need be set out in detail, but the raw data must always be given.

You must also take care with significant figures in presenting and processing data. In calculations, for example, it is appropriate that intermediate results carry one or two extra digits beyond the last significant one, but the raw data and final results must be quoted with the correct number of significant figures.

The number of significant figures in the final calculated result depends on the apparatus used and the accuracy and precision of the measurements taken. This is usually the same as the lowest number of significant figures in any measurement used to determine the final result. It should be noted that the number of significant figures is not the same as the number of figures after the decimal point. For example, the value 20·6 has three significant figures as has $1{\cdot}40 \times 10^{-5}$ but 0·06 and 1×10^{-5} have only one significant figure.

Discussion (conclusion(s) and evaluation)
The 'discussion' section is the most important part of the project–report and in it you must discuss your findings in a critical and scientific manner. It provides you with an opportunity to show off the depth of your knowledge and understanding relevant to the physics in your investigation.

You should demonstrate a reasonable depth of knowledge of the physics involved in discussing and drawing appropriate conclusions from the results of the investigation as a whole. You should take into account limitations of equipment, reliability of methods and sources of error when interpreting your results.

Conclusions and evaluations should be given for each individual experiment.

In your 'discussion' section you must include a clear statement of the overall conclusion(s) and a critical evaluation of the investigation as a whole.

The overall conclusion(s) must relate to the aim(s) of the investigation and they must be valid for the results obtained.

In the evaluation of your procedures, it is important to emphasise positive aspects relating to the procedures as well as commenting honestly on:

- problems overcome
- modifications to procedures
- significance/interpretation of findings

- suggestions for further improvements to procedures
- suggestions for further work

References
A reference is any piece of material to which a writer 'refers' in the text. Each reference must be listed at the end of the project–report to provide information about the source of the material 'referred to'. This allows the reader of the project–report to consult the original work if necessary and is also an acknowledgement of the work of other authors.

Downloading directly from the internet or copying directly from books without acknowledgement is plagiarism. It is also plagiarism to present others' ideas as your own. The purpose of referencing is to show clearly which ideas or words are not your own, to provide enough information for someone else to find the source of those ideas or words, and to present that information consistently. You should use an established approach (eg, Harvard, as illustrated in the examples below).

Within the project–report, there must be a minimum of three references from different sources. Different pages from the same book counts as **one** reference only. Similarly, if you refer to the same website several times, this too counts as **one** reference only. You should also be careful when using a website such as *Wikipedia* since the information it holds may not always be accurate.

Each reference must also be cited in the appropriate part of the text using the author's surname and the year of publication as in the exemplar below:

'A study of variation in wind velocity with altitude showed that hour of measurement was also an important factor' (Grant, 2010).

Where a source has more than one author, additional authors may be represented as, eg (Jones et al., 2006) in the citation but the full list of authors should be given in the reference list.

An example of a suitable referencing system is illustrated below.

Books
Author(s) (surname followed by initials), (Year of publication), *Title*, Place of publication: Publisher, Page number(s).

For example: Tsokos, K. A. (2010) *Physics for the IB Diploma*, Cambridge: Cambridge University Press, pp428–429.

This would be cited in the text as:
'It has been realised that deep-water, long-wavelength sea waves carry a lot of energy. Water waves are very complex and … In this way very high air speeds can be attained, thus coupling the low-frequency water waves with the high-frequency turbine motion (Tsokos, 2010)', ie only the surname(s) of the author(s) and the year of publication in brackets, and nothing else.

Journals/periodicals
Author(s) (surname followed by initials), (Year of publication), Title of article, *Name of Journal*, Volume number (Part number if appropriate), Page number(s).

For example: Stuart, C. (2014) Eccentric Earths: Weird planets where life might lurk, *New Scientist*, March 2014, 2960, pp18–20.

This would be cited in the text as:
'As it is, Earth is sufficiently far away to rotate stably on its axis, with the sun's heat distributed evenly to all sides of the planet. As Earth spins, it traces out a near perfectly circular orbit entirely within the Goldilocks zone … Our unusually large moon is a further boon: its tug ensures that the tilt of Earth's axis — its obliquity — changes very little. All those factors add up to an invitingly constant environment in which life has thrived (Stuart, 2014)', ie, only the surname(s) of the author(s) and the year of publication in brackets, and nothing else.

Websites
As many of the following items as are available must be given:
Author, (Date last updated), Title, [online], Place of publication: Publisher, URL [Accessed date] (because the 'site' may be updated between the time the writer uses it and the point at which a reader refers to it).
For example: Kurtus, R. (January 2011) Equivalence Principles of Gravitation, School for Champions LLC. URL: www.school-for-champions.com/science/gravitation_equivalence_principles.htm
(Visited: August, 2014)

When you are citing websites, it is sometimes difficult to attribute the information used to specific authors; in such cases, the citation should use the organisation responsible for the output published on the web pages consulted, as in the exemplar below:

'A rigid body is an idealization because even the strongest material deforms slightly when a force is applied' (Cliffs Notes, 2013).

Where no clear author or organisation can be attributed, simply list the full URL in the reference list and cite the URL as far as the first '/' in the text and the date visited, eg:
http://www.cimt.plymouth.ac.uk/projects/mepres/alevel/mechanics_ch8.pdf
(Visited: March, 2014) or:
http://www.cimt.plymouth.ac.uk/projects/mepres/alevel/mechanics_ch8.pdf
(Visited: November, 2014) or:
www.cimt.plymouth.ac.uk/projects/mepres/alevel/mechanics_ch8.pdf
(Visited: November, 2014) would be correct but
URL: http://www.cimt.plymouth.ac.uk, visited November 2014 is **not** acceptable.

This must be cited in the text as:
'The constant α is called the angle of phase, or simply the phase, and its value depends on the way in which the pendulum is set in motion. If it is released from rest the angle of phase will be zero, but if it is flicked in some way, the angle of phase will have a non-zero value.'
(cimt.plymouth.ac.uk) is correct **but** (**www.**cimt.plymouth.ac.uk) and (**http://www.**cimt.plymouth.ac.uk) would **not** be acceptable. Dates **must not** be cited in the text.

If web source is dated, include date. If not use 'n.d.'.
The URL and the date visited must be listed, but should not be cited in the text. The date visited must be cited at the back for each website reference and must not be given as a blanket statement such as 'all websites visited November 2014'.

Care should be taken when using information from websites such as *Wikipedia* or those created by private authors, since they may not have been 'peer reviewed' and, as a consequence, may not always be accurate. It is important to identify sources of information that are based on genuine scientific research or knowledge.

Overview of Marking Instructions

Assessment category and criteria	Marks
Abstract ♦ a brief abstract (summary) stating the overall aim(s) and finding(s)/conclusion(s) of the investigation	**1** **(1)**
Introduction ♦ relevant to the investigation ♦ demonstrating an understanding of the physics theory underpinning the investigation ♦ of an appropriate level (ie commensurate with the demands of Advanced Higher Physics)	**4** **(4)**
Procedures ♦ labelled diagrams and/or descriptions of apparatus, as appropriate ♦ clear descriptions of how the apparatus was used to obtain experimental readings ♦ procedures are at an appropriate level for Advanced Higher complexity, ie appropriate level of demand; factors to be considered include: — range of procedures — control of variables — accuracy — originality of approach and/or experimental techniques; — degree of sophistication of experimental design and/or equipment	**2** **2** **3** **(7)**
Results (including uncertainties) ♦ data sufficient and relevant to the aim(s) of the investigation ♦ appropriate analysis of data, eg quality graphs, lines of best fit, calculations ♦ uncertainties in individual and final results	**1** **4** **3** **(8)**
Discussion (conclusion(s) and evaluation) ♦ conclusion(s) is/are valid and relate to the aim(s) of the investigation ♦ evaluation of experimental procedures to include, as appropriate, comment on: — accuracy of experimental measurements — adequacy of repeated readings — adequacy of range over which variables are altered — adequacy of control of variables — limitations of equipment — reliability of methods — sources of errors and uncertainties ♦ coherent discussion of overall conclusion(s) and critical evaluation of the investigation **as a whole** to include, as appropriate, comment on: — problems overcome — modifications to procedures — significance/interpretation of findings	**1** **3** **3**

— suggestions for further improvements to procedures — suggestions for further work ♦ overall quality of the investigation	**1** **(8)**
Presentation ♦ appropriate structure, including informative title, contents page and page numbers ♦ references cited in the text and references listed in standard form, acknowledgements, where appropriate	**1** **1** **(2)**
Total marks	**30**