Advanced Higher Coursework Assessment Task

Advanced Higher Physics

Project

Assessment task

This document provides information for teachers and lecturers about the coursework component of this course in terms of the skills, knowledge and understanding that are assessed. It **must** be read in conjunction with the course specification.

Valid from session 2019-20 and until further notice.

This edition: May 2019 (version 1.0)

Contents

Introduction

This document contains instructions for teachers and lecturers, marking instructions and instructions for candidates for the Advanced Higher Physics project. You must read it in conjunction with the course specification.

This project is worth 30 marks (scaled to 40). This contributes 25% to the overall marks for the course assessment.

This is one of two course assessment components. The other component is a question paper.

Instructions for teachers and lecturers

General information

This information applies to the project for Advanced Higher Physics.

The project assesses the application of skills of scientific inquiry and related physics knowledge and understanding.

The project gives candidates an opportunity to demonstrate 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
- presenting detailed information appropriately in a variety of forms
- processing and analysing physics 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

The project offers challenge by requiring candidates to apply skills, knowledge and understanding in a context that is one or more of the following:

- unfamiliar
- familiar but investigated in greater depth
- integrating a number of familiar contexts

Candidates research and report on a topic that allows them to apply skills and knowledge in physics at a level appropriate to Advanced Higher.

The topic must be chosen with guidance from teachers and/or lecturers.

The project has two stages:

- research
- report

In the research stage, the candidate must plan experiments. The candidate must also collect data through experimental work and analyse this data. They must also gather information from the internet, books or journals to support their understanding of the physics underlying their project.

Candidates must each produce a report on their own research.

Each candidate should keep a record of their work in a daybook, which forms the basis of their report. This daybook should include details of their planning, research, experiments, and recorded data. Typically, there should be data collected from **three or four** related experiments.

The daybook is not required for course assessment and is not submitted to SQA.

Conditions of assessment

Setting, conducting and marking the project

Setting

The project is set:

- by centres within SQA guidelines
- at a time appropriate to the candidate's needs
- within teaching and learning and includes experimental work at a level appropriate to Advanced Higher

Conducting

The project is conducted:

- under some supervision and control
- in time to meet a submission date set by SQA
- independently by the candidate

Marking

The project report is submitted to SQA for external marking.

All marking is quality assured by SQA.

Assessment conditions

Controlled assessment is designed to:

- prevent third parties from providing inappropriate levels of guidance and input
- mitigate concerns about plagiarism and improve the reliability and validity of SQA awards
- allow centres a reasonable degree of freedom and control
- allow candidates to produce an original piece of work

Both stages of the project are conducted under some supervision and control.

This means that:

- candidates do not need to be directly supervised at all times
- the use of resources, including the internet, is not tightly prescribed
- the work an individual candidate submits for assessment is their own
- teachers and lecturers can provide reasonable assistance

The term 'reasonable assistance' is used to try to balance the need for support with the need to avoid giving too much assistance. However, teachers and lecturers should not adopt a directive role or provide specific advice on how to re-phrase, improve responses or provide model answers. Teachers and lecturers must be careful that the integrity of the assessment is not compromised.

The project may involve candidates undertaking a large amount of autonomous work without close supervision. Although candidates may complete part of the work outwith the learning and teaching setting, teachers or lecturers must put in place processes to monitor progress and ensure that the work is the candidate's own and that plagiarism has not taken place. For example, by:

- having regular progress meetings with candidates
- conducting spot-check interviews with candidates
- regularly reviewing candidates' daybooks
- completing checklists to record candidates' progress

Teachers and lecturers must exercise professional responsibility to ensure that the report submitted is the candidate's own work.

Instructions

This assessment is carried out over a period of time. Candidates should start at an appropriate point in the course.

The instructions for candidates outline the requirements for the project. Teachers and lecturers must give these to candidates at the outset. Teachers and lecturers must ensure candidates understand the requirements of the task.

Teachers and lecturers should encourage candidates to keep a daybook to maintain a record of their planning, research, experimental measurements, and analysis. It is important that the teacher or lecturer checks each candidate's daybook regularly to monitor progress and give advice.

Teachers and lecturers must not, at any stage, provide candidates with a template or model answers.

Research stage

The research stage is conducted under some supervision and control. See 'Conditions of assessment' section.

Choosing the topic

At the start of the research stage, the teacher or lecturer must agree the choice of topic with the candidate to ensure that it:

- is appropriate for Advanced Higher Physics
- has associated experimental work that can generate numerical data suitable for graphical analysis
- allows the candidate the opportunity to access all of the available marks

Unless a centre is presenting a large number of candidates (more than 10), the teacher or lecturer must not allow a candidate to choose a topic that may lead to experimental procedures similar to those being carried out by another candidate in the centre.

Centres presenting a larger number of candidates must minimise the number of candidates investigating the same topic. If two candidates in a centre are following the same experimental procedures, the teacher or lecturer must ensure that each candidate carries out research, including experimental work, individually.

There should be no need for candidates in a small presentation group to be investigating topics leading to similar experimental procedures.

Once candidates have agreed the topic with their teacher or lecturer, they must formulate an aim.

Formulating the aim

To ensure the candidate's aim is achievable the teacher or lecturer must provide advice on its suitability, taking into account:

- health and safety considerations
- the availability of resources

Teachers and/or lecturers must not provide candidates with an aim.

After the candidate has formulated an aim, they can progress through the research stage.

The candidate's research involves planning experimental work and gathering data from the experimental work. The number of experiments will depend on the chosen topic, but the experimental phase of the project normally consists of **three or four** related experiments. In any event, candidates should spend approximately **10 to 15 hours on experimental work**.

The candidate's research also involves gathering information from internet/literature sources to support their understanding of the underlying physics.

Candidates may carry out research outwith the direct supervision of teachers and/or lecturers.

Candidates can carry out their research in any order. They do not have to follow the order below.

Experimental research

Teachers and/or lecturers are responsible for ensuring that appropriate risk assessment has been carried out and that candidates have guidance on the safe and correct use of equipment.

Candidates must plan their own experimental work, and so teachers and/or lecturers must not supply instructions for the experimental procedure(s).

Teachers and/or lecturers must not provide candidates with experimental data.

Teachers and/or lecturers must not provide a blank or pre-populated table for experimental results.

Candidates must carry out the experimental work individually. Group work is not allowed.

Internet/literature research

As with experimental research, internet/literature research must be the work of the individual candidate.

Report stage

The report stage is conducted under some supervision and control. See 'Conditions of assessment' section.

Evidence to be gathered

The following candidate evidence is required for this assessment:

- a project report

The project report is submitted to SQA, within a given timeframe, for marking.

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

Volume

The project report should be between 2500 and 4500 words in length, excluding the title page, contents page, tables of data, graphs, diagrams, calculations, references and acknowledgements.

Candidates must include their word count on the project report flyleaf.

If the word count exceeds the maximum by more than 10%, a penalty is applied.

Marking instructions

In line with SQA's normal practice, the following marking instructions for the Advanced Higher Physics Project are addressed to the marker. They will also be helpful for those preparing candidates for course assessment.

Candidates' evidence is submitted to SQA for external marking.

General marking principles

Always apply these general principles. Use them in conjunction with the detailed marking instructions, which identify the key features required in candidates' responses.

Always use positive marking. This means candidates accumulate marks for the demonstration of relevant skills, knowledge and understanding; marks are not deducted for errors or omissions.

Detailed marking instructions

Read the whole report before assigning any marks.

Section	Max mark	Expected response and marking instructions
1 Abstract (1 mark)		
	1	**A brief abstract (summary) stating the overall aim and findings/conclusion(s) of the project.** ♦ The abstract must be either immediately before or immediately after the contents page and must contain a clear statement of the aim and overall findings/conclusion(s) of the project. ♦ The overall findings must be consistent with the conclusion(s) given later in the report, for example in the 'discussion' section, and must relate to the aim.

Section	Max mark	Expected response and marking instructions
2 Underlying physics (4 marks)		
	4	**A description of the physics theory underpinning the project and/or the procedures used that:** ♦ **is relevant to the project** ♦ **demonstrates an understanding of the physics theory** ♦ **is of an appropriate level and commensurate with the demands of Advanced Higher Physics** Mark this section holistically. Award marks for quality. ♦ Candidates must demonstrate an understanding of the underlying physics that is relevant to the project. Terms, symbols and abbreviations used must be clearly defined. Simply stating relationships is not sufficient to show a full understanding. Some justification must be given, such as a derivation. In candidates' accounts of the underlying physics, they must use terms accurately and explain ideas clearly. Diagrams must also be included as appropriate. Ignore a small number of minor mistakes or omissions unless these are fundamental to the physics behind the project. ♦ Significant copying directly from the internet, books or journals may suggest that candidates have not understood the physics involved. Where a candidate copies the vast majority of text verbatim then they are not demonstrating understanding. ♦ Complex diagrams copied and pasted from an internet source, or scanned from a textbook are acceptable as part of the description of the underlying physics. Underlying physics may be found anywhere in the project report, but award marks in this section.

Section	Max mark	Expected response and marking instructions
3 Procedures (7 marks)		
3 a	2	**Labelled diagrams and/or descriptions of apparatus, as appropriate.** ♦ The apparatus must allow the aim of the project to be achieved. If there is no stated aim, award this mark if the aim is obvious from the title of the project report. ♦ Candidates must include clear, labelled diagrams and/or descriptions of the apparatus that they used for experimental work. Clear, uncluttered photographs of assembled apparatus, with appropriate labelling, are acceptable. Circuit diagrams must be included where appropriate. Where necessary, component values must be shown. Simple lists of apparatus, on their own, are not sufficient.
3 b	2	**Clear descriptions of how the apparatus was used to obtain experimental readings.** Candidates must give clear descriptions of how they used the apparatus to obtain their experimental readings. ♦ The procedures should be described well enough for a competent Advanced Higher Physics candidate to replicate. ♦ The number of repetitions and both the range and interval of the independent variable should be included, where appropriate. ♦ The description of procedures must be written in the past tense and impersonal passive voice. If the description is not written in past tense and impersonal passive voice, for example if written as a set of instructions in the imperative voice, then award a maximum of 1 mark for the descriptions of how the apparatus was used. Ignore the use of incorrect tense or voice on one occasion only. Bulleted or numbered points are only acceptable if the statements are sentences and are meaningful and coherent. These statements must make sense if numbers or bullet points were to be removed.

Section	Max mark	Expected response and marking instructions
3 c	3	**Experimental procedures are at an appropriate level of complexity and demand.** Mark this section holistically. Award marks for quality. ♦ The experimental procedures that candidates use in their project must be at an appropriate level of demand for Advanced Higher Physics. Factors to consider when assessing candidates' procedures include: — range of procedures — control of variables — degree of accuracy and precision of measurements — originality of approach and/or experimental techniques — degree of sophistication of experimental design and/or equipment ♦ The level of complexity of experimental procedures can be a reflection of the time spent by candidates on experimental work. Candidates should spend approximately 10 to 15 hours on experimental work.

Section	Max mark	Expected response and marking instructions
4 Results (including uncertainties) (8 marks)		
4 a	1	**Data sufficient and relevant to the aim of the project.** ♦ The experimental data that candidates collect must be relevant to the aim of the project. The data candidates collect and present must also be sufficient in quantity and to a degree of precision appropriate for the instruments used. ♦ All readings must be shown — not just mean or derived values.
4 b	4	**Appropriate analysis of data, for example quality of graphs, lines of best fit, calculations.** Mark this section holistically. Award marks for quality. ♦ Candidates need to show an analysis of their raw data appropriate to the project and at a level commensurate with Advanced Higher. ♦ Graphical analysis must be used, where appropriate. ♦ Appropriate abbreviations may be used for variables and units.
4 c	3	**Uncertainties in individual readings and final results.** ♦ Candidates should quantify all (calibration, scale reading and random) uncertainties in measurements used in their analysis and combine these to determine the uncertainty in each measured value. ♦ Candidates must combine the uncertainty in each measured value to determine the uncertainty in the final result. It is good practice to show clearly how the uncertainty in the final result has been calculated or estimated. Candidates' treatment of uncertainties must be appropriate for Advanced Higher Physics; the project report must include evidence that relates to the mandatory knowledge for units, prefixes and uncertainties detailed in the *Advanced Higher Physics Course Specification*.

Section	Max mark	Expected response and marking instructions
5 Discussion (conclusion(s) and evaluation) (8 marks)		
5 a	1	**Valid conclusion(s) that relate to the aim of the project.** Candidates must include valid conclusion(s) that relate to the aim of their project and are supported by experimental data. Conclusion(s) can be given after the results of each experiment.
5 b	3	**Evaluations of experimental procedures to include, as appropriate, comment on:** ♦ **accuracy and precision 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 uncertainties** Mark this section holistically. Award marks for quality. Candidates must include an evaluation of each experiment. It is often appropriate to include this after the results of each experiment. This should be a significant part of candidates' project reports and must focus on factors affecting the quality of their experimental work. Candidates should include as many factors as possible and suggest improvements to procedures, with justifications as appropriate.

Section	Max mark	Expected response and marking instructions
5 Discussion (conclusion(s) and evaluation) (8 marks)		
5 c	3	**Coherent discussion of overall conclusion(s) and critical evaluation of the project as a whole, to include, as appropriate, comment on:** ♦ **selection of procedures** ♦ **problems encountered during planning** ♦ **modifications to planned procedures** ♦ **interpretation and significance of findings** ♦ **suggestions for further improvements to procedures** ♦ **suggestions for further work** Mark this section holistically. Award marks for quality. Candidates must include a discussion of their overall conclusion(s), together with an evaluation of the project as a whole. This should be a wide-ranging discussion of the project. Candidates have the opportunity to explain what they have learned as a result of the project, and the significance of their findings.
5 d	1	**A report that indicates a quality project.** ♦ This is a quality mark for the standard of the project, not just the discussion part of the report alone. ♦ Award this mark for a report that indicates a good, competent project, well-worked through.

Section	Max mark	Expected response and marking instructions
6 Presentation (2 marks)		
6 a	1	**A report with an appropriate structure, including informative title, contents page and page numbers.** ♦ The project report structure must be easy to follow. ♦ An informative title and contents page are essential. The contents page must show the sections within the report along with their corresponding page numbers and the pages throughout the report must be numbered. Do not penalise occasional missing page numbers, for example on graph pages.
6 b	1	**References to at least three sources cited in the text and listed at an appropriate point in the report. Citing and listing must use either Vancouver or Harvard systems.** ♦ The references must be: — relevant to the aim of the project — cited within the project report — listed at or near the end of the project report — in either Vancouver or Harvard referencing systems ♦ To be acceptable: — Internet sources must be referenced by as many of the following as possible: author(s) (year), article title, website title, full URL, date of access. — Book sources must be referenced by as many of the following as possible: author(s) or editor(s), title of book, edition number (if other than first edition), place (city) of publication, publisher's name, year of publication, page numbers. — Journal sources must be referenced by as many of the following as possible: author(s), year of publication, title of journal article, title of journal, volume number, issue number, page numbers of the article. Ignore additional references cited or listed incorrectly.
Total	**30**	

Instructions for candidates

This assessment applies to the project for Advanced Higher Physics.

This project is worth 30 marks. This contributes 25% to the overall marks for the course assessment.

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
- presenting detailed information appropriately in a variety of forms
- processing and analysing physics 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

This project has two stages.

- research
- report

Your teacher or lecturer will let you know if there are any specific conditions for doing this assessment.

In this project, you have to investigate a topic in physics by doing research. You will work individually to gather data/information from your own experiments and from internet/literature research. This may involve you carrying out a significant part of the work without supervision.

Your research involves planning experiments and gathering data. An Advanced Higher Physics project typically consists of **three or four** related experiments. You should plan to spend approximately 10 to 15 hours doing experimental work.

You will gather information from internet/literature sources to support your understanding of the underlying physics. From the start of your project, and throughout, you should maintain a record of your work in a daybook.

You then produce a report on your project.

Your teacher or lecturer will not mark your report at any point. It is sent to SQA for marking.

Research stage

At the start of your project, it is advisable to set up a timescale with start dates and deadlines for each stage of your project, for example:

Stage	Start date	Tasks	Deadline dates
Research — planning		Read the 'Instructions for candidates'.	
		Discuss your choice of topic with your teacher or lecturer.	
		Decide on the aim of your project. Discuss the suitability of your aim with your teacher or lecturer.	
		Research the physics underlying your chosen topic.	
		Research possible experiments and show your teacher or lecturer a detailed plan of the experiments you intend to carry out.	
Research — experimental		Check that the apparatus will be available for you whenever you need it.	
		Complete the experimental work. Allow time to carry out repeated measurements. Allow 10 to 15 hours for your experimental work.	
		Analyse your experimental results, including uncertainties, by drawing graphs and performing calculations.	
		Consider your conclusion(s).	
		Evaluate your experiments.	
Report		Complete a draft of your report.	
		Finalise your report.	

You should include a copy of this table in your daybook.

Choosing your topic

- You need to choose a topic in physics to investigate.
- You must agree your topic with your teacher or lecturer.

Keeping a daybook

Your daybook should contain a complete record of the work you carry out during your project.

Your daybook should include:

- the date of each entry in the daybook
- a description of your experimental procedures
- all measurements, which should be tabulated
- any observations
- analysis of experimental data, including uncertainties (Plotting graphs while data is being collected allows rogue points to be identified. Ongoing analysis of your experimental data allows you to plan what you will do next.)
- notes on any discussions with your teacher or lecturer and any advice given
- information collected from internet/literature sources, including references

It is important to write your entries into your daybook so that it is easy to follow and understand when you produce your report.

It is important that you ask your teacher or lecturer to check your daybook regularly and take their advice.

Deciding your aim

- Once you have chosen your topic, you need to decide what the aim of your project is.
- Remember that you need to plan, carry out and collect data from experiments that relate to your aim.
- Your teacher or lecturer will give you advice on the suitability of your aim.

Experimental research

- When planning your experiments, remember that they must allow you to take measurements and plot scatter graphs.
- When carrying out your experiments, you must work on your own.
- Make sure you take a sufficient number of measurements over a wide enough range to meet the aim of your project.
- You must repeat measurements.
- You must estimate both the scale reading uncertainty in all the measurements you make, and record the calibration uncertainty in the instruments you use.

Internet/literature research

- In your report, you will need to show that you understand the physics underlying your project. You can use information from websites, books and/or journals to help you write your description of the underlying physics. In your report, you will need to show your understanding by writing this account using your own words.
- It is important that you record where you get your information. In your report, you will need to cite and reference at least three of your sources using either Vancouver or Harvard referencing systems.

Report stage

Producing the report

The report must be all your own work.

Resources

The information you recorded in your daybook should form the basis of your report.

You can access any resources you need to write your report.

Guidance on producing your report

The following table shows the marks allocated to each section in your report.

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

Using headings may help to make your report clear.

Title page

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

Abstract

In your abstract, you must state the aim and overall findings/conclusion(s) of the project. The abstract must be brief and should be immediately before the contents page. Although it appears early in the report, as the abstract summarises the project, it may be one of the

last things you write. Your overall findings must be consistent with your conclusion(s) and must relate to the aim.

Contents page

This page must list the sections within the report and their corresponding page numbers, for cross-referencing purposes. It is essential that you number all pages in the report.

Underlying physics

You must include a description of the underlying physics that is relevant to the project. This account must show your understanding of the physics underlying your chosen topic. You should derive any relationships you use and define abbreviations and symbols.

You might draw on a variety of sources of information when you are researching your chosen topic. In your account of the underlying physics, use terms accurately and explain ideas clearly. You should also include diagrams, as appropriate.

Your report must reference at least three sources of information you used. You must cite them in the text and list them at the end of the report. The information from the sources could either have supported your understanding of the physics or helped you to plan your experiments.

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

Procedures

This section must contain an account of the procedures you carried out in your project. The procedures must be clearly described in sufficient detail to allow the project to be replicated. Include details of all the apparatus, methods and materials used to obtain your data.

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

The experimental procedures that you use in your project 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. Clear, uncluttered photographs of assembled apparatus, with appropriate labelling, are acceptable. You should include circuit diagrams, including the value of components, where appropriate. Simple lists of apparatus, on their own, are not sufficient.

You must also include clear descriptions of how you used the apparatus to obtain your experimental results. You must include sufficient detail to allow your project to be replicated by another person. Include the range and interval of measurements and number of repetitions, where appropriate.

You must write the description in the past tense and use the impersonal passive voice.

Bulleted or numbered points are only acceptable if the statements are sentences and are meaningful and coherent. They must make sense if the numbers or bullet points were to be removed. Your description must not be a list of instructions.

Results (including uncertainties)

The results must be relevant to the aim of your project.

In the results section, you must provide all raw data as well as processed or derived data. Raw data are the measurements you actually record in each experiment.

You must include all the measurements taken (not just the mean values) and show by sample calculation how they were processed to produce a final result.

You should show the treatment of uncertainties in this section. You must quantify all (calibration, scale reading and random) uncertainties in measurements used in your analysis. You must combine these to determine the uncertainty in each measured value, and combine the uncertainties in each measured value to determine the uncertainty in the final result. This may include the determination of the uncertainty in the gradient or intercept of a line of best fit.

You must present measurements and processed data clearly, with appropriate use of tables, scatter graphs and calculations. Tables must have appropriate headings and units must be specified. Graphs must have appropriate axis labels with units specified.

For your graphs, you must include tables of measurements and any derived values that you used to plot your data points. A graph on its own is not sufficient — you must also present the data from which it has been derived.

When drawing a graph, you must ensure that:

- it is large enough to allow the accuracy of plotting to be checked
- 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 points are plotted accurately
- a line of best-fit is drawn, where appropriate

When you use graphing software to present graphs, it is important to adapt the axes to suit the data range so that you can present the results in the most appropriate way. You must include major and minor gridlines and use symbols for data points that are clear, but not excessively large.

You must clearly structure any calculations. When you repeat the same type of calculation for different raw data, you only need to set out one sample calculation in detail, but you must always give all the raw data.

You must take care with significant figures in presenting and processing data. In calculations, for example, it is appropriate that intermediate results carry a number of

extra digits beyond the last significant one, but you must quote the raw data and final results to an appropriate number of significant figures.

The number of significant figures in the final calculated result depends on the apparatus used and the 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. The number of significant figures is not the same as the number of figures after the decimal point. For example, the values 20·6 and $1{\cdot}40 \times 10^{-5}$ each have three significant figures. However, 0·06 and 1×10^{-5} have only one significant figure.

Discussion (conclusion(s) and evaluation)

In your discussion section, you must include a clear statement of the overall conclusion(s), an evaluation of your procedures and a critical evaluation of the project as a whole.

The discussion section is an important part of the report, and in it you must discuss your findings in a critical and scientific manner. It gives you an opportunity to demonstrate the depth of your understanding of the experimental physics in your project.

You should give conclusions and evaluations for each individual experiment.

You should demonstrate understanding of the physics involved when you are discussing the results of the project as a whole.

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

In the evaluation of your procedures, you should comment on the accuracy and precision of your measurements, and the source(s) of dominant uncertainties. You should make suggestions for improvement, including justifications.

You could consider:

- the accuracy and precision of experimental measurements
- the adequacy of the number of repeated measurements
- the adequacy of the range over which variables are altered
- the adequacy of control of variables
- limitations of equipment
- the reliability of methods
- sources of uncertainty

In the critical evaluation of the project as a whole, it is important that you emphasise positive aspects relating to the procedures, as well as commenting on:

- selection of procedures
- problems encountered during planning
- modifications to planned procedures
- interpretation and significance of findings

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

Presentation

You should use a structure for your report that is clear and flows logically. Your report must have a title page with an informative title. It must have a contents page with section headings and their corresponding page numbers. You must number all the pages in your report.

You must cite and reference at least three different sources of information that you have used.

Different pages from the same book count as **one** reference only. Similarly, if you refer to different areas of the same website, this too counts as **one** reference only.

A reference is any piece of material that a writer refers to in the text. You must list each reference at the end of your report to provide information about the source of the material referred to. This allows the reader of your report to consult the original work if necessary and is also an acknowledgement of the work of other authors.

Copying directly from the internet, books or journals 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 **must** use either Vancouver or Harvard referencing systems. Guidance on citing and referencing textbooks, websites and journals is given below:

Textbooks

1 Vancouver

You must cite books in the body of the text by a number, for example [1], (1) or [1].

You may include the page numbers with the citation, for example [1, p.22] or with the reference, for example (p.38–42). This is useful when you are citing different pages in the same book where it has been used more than once. Citations can also be listed using the author's name, but should still have the number, for example Tyler[1]. If you are citing multiple sources in one section of the report, you can list all of these in the same place, for example (1, 3, 4). When there are a number of authors, you should include at least one of the authors and list the others as 'et al', but you should still include the citation number, for example Sears et al[2].

Include as many of the following details as possible in your references:

- author(s) or editor(s): author's forename and/or initials and surname
- title of book
- edition number (if other than first edition)
- place (city) of publication

- publisher's name
- year of publication
- page numbers

For example:

1 J.O. Bennett, M.O. Donahue, M. Schneider, M. Voit *The Cosmic Perspective*. 8th Edition. New Jersey: Pearson Education; 2016. p. 47-52

2 Harvard
You must cite books in the body of the text in parentheses with the author's surname and the year of publication, for example (Tyler, 1977).

You may include the page numbers with the citation, for example (Tyler, 1977 pp. 45–48). Note: if there are three or fewer authors, you should cite them all, for example (Horowitz & Hill, 1989). When there are four or more authors, cite the first author and follow this with 'et al', for example (Bennett et al, 2014).

Include as many of the following details as possible in your references:

- author(s) or editor(s)
- title of book
- edition number (if other than first edition)
- place (city) of publication
- publisher's name
- year of publication
- page numbers

For example:
Tyler, F *A Laboratory Manual of Physics in S.I. Units*. 5th Edition. London: Edward Arnold; 1977. pp 45-48

Websites

1 Vancouver
You must cite websites in the body of the text by a number, for example [1], (1) or [1].

Include as many of the following details as possible in your references:

- author/editor (use the corporate author if no individual author or editor is named)
- title (this should be in italics)
- the URL
- the date of access (this should be enclosed in square brackets)

For example:

1 Dumé, B. *Could sound move at the speed of light?*
Available from: *http://physicsworld.com/cws/article/news/2005/nov/01/could-sound-move-at-the-speed-of-light* [accessed 01/05/19].

2 Harvard
You must cite websites in the body of the text in parentheses with the author's surname and the year of publication, for example (Dunning, 2017). If no date is given, use 'n.d.', for example (author, n.d.).

Include as many of the following details as possible in your references:

- author (year)
- article title (this should be in italics)
- website title
- URL
- the date of access

For example:
Dunning, H. (2017). *Theory that challenges Einstein's physics could soon be put to the test*. [online] www.imperial.ac.uk. Available at: http://www3.imperial.ac.uk/newsandeventspggrp/imperialcollege/newssummary/news_24-11-2016-10-12-58 [Accessed 1 May 2019].

When no clear author or organisation can be attributed, cite the URL as far as the first '/' in the text, but do not include 'http://www.', for example (cimt.org.uk) and list the full URL in the reference list with the date accessed, for example:
https://www.cimt.org.uk/projects/mepres/alevel/mechanics_ch8.pdf [Accessed: May 2019]

Journals: print

1 Vancouver
You must cite journals in the body of the text by a number, for example [1], (1) or [1].

Include as many of the following details as possible in your references:

- author(s)
- title of journal article
- title of journal (this should be in italics)
- year of publication
- volume number
- issue number (this should be enclosed in brackets)
- page numbers of the article

For example:
Davies R., Bacon R., de Zeeuw T. Sauron. *Frontiers UK particle physics, astronomy and space science*. 2004:18 (winter):14–15.

2 Harvard
You must cite journals in the body of the text in parentheses with the author's surname and the year of publication, for example (Ball, 2012).

You may include page numbers, for example (Ball, 2012 pp. 46-50). Note: if there are three or fewer authors, you should cite them all, for example (Davies, Bacon & de Zeeuw, 2004). When there are four or more authors, cite the first author and follow this with 'et al', for example (Bennett et al, 2014).

Include as many of the following details as possible in your references:

- author
- year of publication (this should be enclosed in brackets)
- title of journal article
- title of journal (this should be in italics)
- volume number
- issue number
- page numbers of the article (do not use 'p.' before the page numbers)

For example:
Edgecock, R. (2004) Cooling muons with MICE. *Frontiers UK particle physics, astronomy and space science*. 2004:18 (winter):24–25.

A number of websites include detailed guides for referencing, for example:

Vancouver: https://www.imperial.ac.uk/media/imperial-college/administration-and-support-services/library/public/vancouver.pdf

Harvard: https://www.imperial.ac.uk/media/imperial-college/administration-and-support-services/library/public/harvard.pdf

Online referencing tools can automatically format the citation and reference for a chosen style. You should consider using one of these.

Summary

You can use this table to check you have covered all the sections in the report.

Section	Expected response	Mark allocation
Abstract	A brief abstract (summary) stating the overall aim and findings/conclusion(s) of the project.	1
Underlying physics	A description of the underlying physics that: ♦ is relevant to the project ♦ demonstrates an understanding of the physics theory underpinning the project ♦ is of an appropriate level and commensurate with the demands of Advanced Higher Physics	4
Procedures	Labelled diagrams and/or descriptions of apparatus, as appropriate.	2
	Clear descriptions of how the apparatus was used to obtain experimental readings.	2
	Procedures are at an appropriate level of complexity and demand. Factors to be considered include: ♦ range of procedures ♦ control of variables ♦ accuracy and precision ♦ originality of approach and/or experimental techniques ♦ degree of sophistication of experimental design and/or equipment	3
Results (including uncertainties)	Data is sufficient and relevant to the aim of the project.	1
	Appropriate analysis of data, for example, quality of graphs, lines of best fit, calculations.	4
	Uncertainties in individual readings and final results.	3
Discussion (conclusion(s) and evaluation)	Valid conclusion(s) that relate to the aim of the project.	1
	Evaluations of experimental procedures to include, as appropriate, comment on: ♦ accuracy and precision 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 uncertainties	3

Section	Expected response	Mark allocation
	Coherent discussion of overall conclusion(s) and critical evaluation of the project as a whole, to include, as appropriate, comment on: ♦ selection of procedures ♦ problems encountered during planning ♦ modifications to planned procedures ♦ interpretation and significance of findings ♦ suggestions for further improvements to procedures ♦ suggestions for further work	3
	A report which indicates a quality project.	1
Presentation	Appropriate structure, including informative title, contents page and page numbers.	1
	References cited in the text and listed at an appropriate point in the report. Citing and listing using either Vancouver or Harvard referencing system.	1
Total		**30**

Administrative information

Published: May 2019 (version 1.0)

History of changes

Version	Description of change	Date

Note: you are advised to check SQA's website to ensure you are using the most up-to-date version of this document.

Security and confidentiality

This document can be used by SQA approved centres for the assessment of National Courses and not for any other purpose.