

# Undergraduate Mathematics Projects

## Information for students 2008–9

We expect that carrying out your third year group project will be a rewarding and enjoyable experience. As this is the first year that we have run group projects in mathematics at City, we will make particular efforts to ensure that your projects all run smoothly. The following notes are intended to help you understand what will be required for a successful project. More information can be found on the project webpages [3]

### What makes a good project?

A good project will give a clear, coherent explanation of a piece of mathematics not previously known by the student. This may be the solution to a problem (together with an explanation of the methods used) or a review of a new area of mathematics. Note that it is *always* necessary to have an original component to the work: if the aim of the project is to solve a problem then this may be an original calculation; if the project is a review then there will need to be original examples.

There will be marks for the quality of the content as mathematics, but also for the clarity of presentation, the references, the contribution of each student, and other aspects which will be discussed below. In total the written report will contribute 50% of the final mark. The remaining marks will come from the oral presentation at the end, which will include a presentation by the group together with individual questions.

A detailed mark scheme for the written component of your project is available on the web at:

[http://www.staff.city.ac.uk/v.caudrelier/Projects/Report\\_Assessment.doc](http://www.staff.city.ac.uk/v.caudrelier/Projects/Report_Assessment.doc)

and a corresponding version for the oral assessment will appear nearer to the date of the presentations. You will see from the mark scheme that there are various categories of marks involved; we will now consider each of these in detail.

### Project content

The aim of your project is to explain some new mathematics. Although the work may be based on some standard theory which you learn during the project, there must be an original component (which will typically be new calculations or examples).

We are looking for quality, not quantity. It is a common mistake for students to assume that the more they write the better they will do. While of course it is necessary to have enough material in your project, you should not simply aim for the maximum number of pages. Projects that are too long often gain lower marks because the material has been less well understood or less well presented. We expect projects to be 30-40 pages long. While there may be good reasons for longer (or shorter) projects, such as having many large diagrams or tables, this should be the exception rather than the rule. One of the skills we are looking for is an ability to pick out the most important elements and construct a coherent project from them, rather than just swamping the reader with anything even vaguely relevant.

### References and Plagiarism

It is **very important** that you understand what plagiarism is and how to avoid it. Last year three project students were found guilty of plagiarism in mathematics. All the projects were failed: in the least serious case the student was allowed to submit a new project for a pass mark of 40%, the second student was allowed to submit a new project to obtain the credit but with a mark of 0%, and the most serious case was referred to the main University Misconduct panel who expelled the student without a degree.

According to Wikipedia [2] plagiarism is *the use or close imitation of the language and thoughts of another author and the representation of them as one's own original work*.

(It is interesting to note that the following definition of plagiarism appears at [5]: *The unauthorised use or close imitation of the language and thoughts of another author and the representation of them as one's own original work*. One of these two definitions would appear to be plagiarised!)

The main way to avoid a charge of plagiarism is to use appropriate referencing. Your project is not expected to be a completely original contribution to Mathematics, and so we will expect to see references to the sources which you have used. On the other hand, no reader wants to be swamped with references on every line. There are several ways to strike an appropriate balance, of which I recommend the following.

There are (roughly) three classes of references that might appear in your project. The first is a general reference where you base the material in a section or chapter on one or more sources. If you are explaining some standard theory, following one or two texts, then there is no need to add a reference at the end of every line. At the start of the section you might include a sentence (perhaps at the end of the description of what the section is about) of the form “The following section is based on [x].” (Here “x” will refer to your reference list at the back of the project. We will discuss the format of references later in this section.) The reader will now know that anything which is not referenced is based on [x], and will know where to look if they want more information. If the whole project is based on one or two main references I recommend that you mention this at the end of your introduction. This is in addition to a reference in each section or chapter that refers to them.

The second kind of reference you may have is to a fact which you wish to assert but which the reader has no evidence for. For example you might wish to say that the mathematics being described was used to help man fly to the moon — in which case the reader is going to want evidence of why you believe this to be true! Such a reference should appear at the point where the fact appears; for example as “this was used in the first moon mission [x]”.

The third kind of reference is where you use a figure or other data which you have copied from somewhere. This *must* be referenced at the point where it is used. Even if you redraw the figure or restate the data you should reference it. Similarly if you include an example in your project the reader will assume that it is your own work unless you state otherwise. In your project this should be the case, but very occasionally you may need to use an example from one of your sources. If this is the case you *must* reference it to avoid a charge of plagiarism. However we expect examples to be your own, so there had better be a good reason for copying from elsewhere.

Even if you cite a source, you may still be penalised for excessive copying or paraphrase. If you quote directly from a source it must be *obvious* that the text is a quote. You will get no credit for copying word for word a lengthy piece of text, or for changing it in a trivial manner. You should always try to explain in your own words. An example of how this might be done can be found at

<http://www.staff.city.ac.uk/v.caudrelier/Projects/plagiarism.html>

Many students find it hard to change the original text; they often feel that what they write is worse than the original. This is one of the key skills you are required to develop during your project, so you will need to be prepared to practice. One method I recommend to my students is to break the material into manageable sections (perhaps a paragraph or two, or a page), read it, and then try to write down a version without looking at the original. This should change the way it is expressed, and you can then go back and check there are not any errors while still having a version which is your own.

A good way to demonstrate understanding is to add more detail — your own examples, or comments on errors the reader might make, or more detailed explanations of steps which are done quickly in the original. Most student find that their source material can be quite hard to follow; if this is the case for them then the same will be true for their readers, so why not explain more carefully the steps which caused confusion?

Some of the best projects have contained material you would not expect to find in standard textbooks, for example warnings of errors that the reader might make in understanding or applying the theory. If you have to explain a proof, you may find it helpful to illustrate how the proof works at each stage with an example (although an example is *not* a substitute for a proof).

References are not just there to avoid a charge of plagiarism, but also to help the reader. So we need a system that is clear and easy to follow. A common system in mathematics is to number the references in alphabetical order by the author, as has been done in this document. If there is no author (for example you are referring to a webpage) then you have to decide what to do. One method is to collect all such references at the beginning or end of the list.

It is not very useful for a reader to be referred to a 300 page book when you are actually only using a very small part of it. To give a more detailed reference than just [x], you may add more information in the brackets. Thus while your introduction might just refer at the end to [4], if a chapter is based on a single section then you could refer at the start of that chapter to [4, Section 6]. You can put anything in the bracket that helps the reader, for example [4, Theorem 2.1], or even [4, remarks after equation (4)]. Similarly for webpages: don't just cite Wikipedia — either give a precise reference such as [2], or use the format [1, Plagiarism]. The latter method is useful if you wish to have many references to a single source but don't want to have loads of slightly difference items in your reference list.

Your reference list should be in a standard format. For books you should include the author, title, publisher, and year of publication. For papers (such as [4]) you should include the journal title, the volume number, and the pages. For web pages include as much information as is available from this list. Pick a format that you are happy with and stick to it. Examples of different formats can be found in the reference lists at the back of most maths books.

*Every book in the reference list should be referred to in the text!* In some subjects (such as history) there are two lists, references and bibliography, where the latter refers to general texts which are relevant but are not directly referenced. But this is not standard in mathematics. If you cannot find a reason to include a given reference somewhere in the introduction or conclusion (or of course the main body of the project) then it is hard to imagine why you want to refer to it...

The university has developed a module called OLIVIA on Cityspace about managing information. Much of this is relevant to your project, and in particular there are sections on referencing and plagiarism. *You should all work through this module: it will be assumed that you have done so, and ignorance of its contents will be no excuse if you are charged with plagiarism.*

### **Abstract**

All projects will begin with an abstract. This should be a *brief* summary of the project which details the main achievements of the project. I would recommend that this should be no more than 100-150 words (although some people accept slightly longer abstracts than this).

The point of an abstract is to enable an expert to assess whether your document covers matters of interest to them. Thus it should *not* explain or justify anything, *nor* say how interesting/exciting/original it is. Instead it should contain clear statements of the main points, so that the expert reader can decide if it is what they are looking for. (For a student project one might imagine that the abstract is for a lecturer who is deciding whether the project would cover the right material to be used as course notes for a module.)

I usually recommend picking out the five most important points which the reader should be aware of, and summarising them. Do not worry if there are words which the non-expert might not understand; they are not the target audience. Here is an example of an abstract from a published paper [4]:

We classify all homomorphisms between Weyl modules for  $SL_3(k)$  when  $k$  is an algebraically closed field of characteristic at least three, and show that the  $\text{Hom}$ -spaces are all at most one dimensional. As a corollary we obtain all homomorphisms between Specht modules for the symmetric group when the labelling partitions have at most three parts and the prime is at least three. We conclude by showing how a result of Fayers and Lyle on Hom-spaces for Specht modules is related to earlier work of Donkin for algebraic groups.

Do not worry that you do not understand all of the words! There are no explanations of the technical vocabulary, and no reasons are given for why the work is important. Instead notice that the abstract is almost a list: *We classify X . . . , when something is at least three, and show that the Y are all Z. As a consequence we obtain W and show that a result of U is related to V.* These are the 4 main results: the original paper is almost 50 pages long, and contains a variety of new results in 12 chapters, but the abstract restricts to just the key points, and takes less than 100 words to do so.

In a student project you will not be proving new theorems, but the idea is similar. Pick out the main achievements of the project and mention each in turn. Your project will be considerable shorter than the paper referred to above, so there is no excuse for a lengthy abstract!

## Introduction and Conclusion

The introduction of your project should attract the non-expert reader to read the project, and outline the structure of the project and the main results. You should aim it at the level of a fellow third year student, and try to write something which would explain why he or she might want to read the remainder.

You might think of the introduction as falling into two sections. The first will explain the context of the project — why is it interesting, how is it useful, perhaps some of the history behind the subject. This is perhaps the hardest part of the project to write, and *should not be attempted until the rest of the material is complete*. There is no point trying to write an introduction until you know what your project will contain, but many students try to!

The second section of your introduction will outline the content of the project. You should discuss what will be done in each chapter or section, and the reader should understand that there is some kind of plan connecting the project together rather than it just being a random collection of topics which have been thrown together. This is relatively easy to write once the rest of the project has been written.

The introduction should be *non-technical*; there should be no formal definitions or other pieces of new mathematics. It should be understandable by any other third year maths student. It is a common mistake to confuse the introduction with chapter 1, which is where the basic definitions and other technical material should be introduced.

The conclusion is a short section at the end of your project, which is in some ways the mirror image of the introduction. You should begin by summarising the main achievements of the project, and the main conclusions. For example you may wish to comment on the usefulness or practicality of the results obtained. Then you should give the reader a brief outline of possible further lines of study, with references. This helps the interested reader who wants to learn more, and also allows you to cite topics and references which you would like to mention but have not been able to cover in the project itself. This also allows you to demonstrate that you understand how the material you have covered fits in to the bigger picture.

## Presentation

There are some marks for the presentation of your project. These are not just for how pretty your project is, but cover the clarity and coherence of the presentation. If the material in a project is poorly organised, or confused, this will affect your presentation mark. You may wish to have numbered sections and chapters, or theorems and examples. If so make sure that the numbering is consistent and does not repeat or have gaps! Make sure that reference numbers in the text are correct.

You should prepare your project with a suitable word processor. Mathematicians use a free typesetting language called LaTeX which is very powerful and allows for the display of complicated equations. However it is quite complicated for beginners. You should investigate what tools are available for you to present your mathematical formulas clearly. Diagrams should generally be prepared electronically.

It is not necessary to have exciting colours and complicated graphics to get a good mark for presentation. A clear, well organised text will often score at least as well as a flashy document.

## Contribution of students

As this is a group project we will be considering how well each group works together as a team. The project supervisor will assess each student on the basis of their contribution to the project meetings. *Thus it is important that you attend all of your project meetings and actively participate*. Supervisors will also monitor the general contribution of each student to the progress of the project, and may ask you about your work during the project meetings.

*At the end of the project you will be required to hand in a short (no more than one page) outline of your contribution to the project*. If there are areas to which you made a particularly significant contribution then these should be highlighted.

These outlines will not be marked, and you should be honest about your contributions. In particular, students may be asked some questions during the final oral component on the basis of the topics which they say

they have contributed most to — if you are unable to answer topics on such questions this will not be very impressive!

### Oral presentation and questions

At the end of the module each group will be expected to give an oral presentation to a small panel of assessors. This should last no more than 15 minutes. It is up to each group to decide on the best format for such a presentation; you may wish to all contribute or instead to have one or two main presenters. The group as a whole will get a mark for the quality of the presentation. This will include both its content and the manner of its delivery.

The content of the presentation can be on any aspect of the project. 15 minutes is a very short time — if you look at your lecture notes for a 45-50 minute lecture you will probably find that this is only enough time for about 1 side of material. Thus you will have to think carefully about the best topics to cover in the time available, and how to explain what you have done in a way that will be comprehensible to the listener. We will be looking for evidence of a plan and for a good structure for the talk.

It is up to each group to decide what format to present their material in. You will probably want to use some form of electronic presentation such as PowerPoint or similar. We will consider the effectiveness of your visual aids. Note that (as for the project presentation mark) this is not necessarily to do with the prettiness of the presentation, but rather the clarity and structure of the material presented. It is a common error to try to squeeze too much material onto a slide, or rattle through far too many slides in an attempt to display as much material as possible. We recommend that you practice the presentation in advance to get feedback on the clarity and speed, and to ensure that it fits into the time available.

At the end of the presentation each student will be separately asked a number of questions about the project. As mentioned above, these may possibly be influenced by your statement which outline your major contributions. However, all students will be expected to have a working knowledge of *all* of the material covered in the project. There will be a significant component of the presentation mark devoted to this aspect, and you should note that students who have made a limited contribution to a project are easily detectable under such questioning.

Many mathematics students are nervous about oral presentations. However they are a key skill which you will need to be able to perform effectively in your future career. We introduced presentations for the maths in schools projects two years ago, and the students who took part were very successful.

## References

- [1] *Wikipedia*, <http://en.wikipedia.org/>.
- [2] *Wikipedia: Plagiarism*, <http://en.wikipedia.org/wiki/Plagiarism>.
- [3] V. Caudrelier, *Third year projects 2008/9*,  
[http://www.staff.city.ac.uk/v.caudrelier/Projects/Projects\\_main.html](http://www.staff.city.ac.uk/v.caudrelier/Projects/Projects_main.html).
- [4] A. G. Cox and A. E. Parker, *Homomorphisms between Weyl modules for  $SL_3(k)$* , *Trans. AMS* **358** (2006), 4159–4207.
- [5] A. Rosborough and M. Kreicker, *DMS computer applications: Glossary*,  
<http://www.dmscompapp.com/PGlossary.htm>.