Projects for MATH549 Maple/LaTeX

October 2008

This handout gives some details about the Maple/LaTeX project which forms the assessed part of MATH549. It is important that you understand clearly what will be required for this project, so please feel free to ask me if there's anything that you don't understand.

1 Requirements of the project

Your project should be written during the second half of the semester — the deadline for submission is Friday 19th December at 3pm. (In contrast to the deadlines for the exercise sheets, this one is firm, and marks will be deducted for late submission in accordance with University policy.) You should submit 3 printed copies of your project to Shirley Farrell in Room 516 (no need for fancy binding, staples are fine), and also email all of your LaTeX and Maple files both to me and to your supervisor.

The aim of the project is to demonstrate your ability to use LaTeX and Maple well, while investigating some mathematical area or problem as agreed with your supervisor. The marks for the project are allocated as follows: 40% for the quality of your Maple programs; 30% for the quality of your LaTeX typesetting; and 30% for mathematical content. In view of this mark-scheme, you should note the following:

Maple Since 40% of the marks are awarded for your Maple programs, you will *not* get high marks for Maple if you simply do a few calculations, plots, and so on in a Maple worksheet. You should either write some fairly substantial programs, or develop a "toolkit" of shorter programs suitable for investigating problems in the area you are studying. It is important that both you and your supervisor are aware of this when choosing a topic for your project — it's possible that your supervisor won't have much experience of Maple, in which case it's up to you to ensure that there is sufficient opportunity for writing worthwhile programs.
You should include all of your Maple code, together with appropriate discussion and examples of its use, in an appendix of your project. Marks will be awarded for error-checking and for good commenting of your programs. You should put the procedures you write in a separate text file or files.

LaTeX Most students are capable of producing a reasonable-looking LaTeX document after doing the taught component of this module. To get high marks in the LaTeX component, it's therefore necessary to pay attention to details of the typesetting as well as the general appearance of the project. In particular, I can get very fussy about such things as: writing things like n and x for the mathematical symbols n and x; poor punctuation at the end of displayed equations (and elsewhere); bad line breaks (where something important is made hard to read because it's split over two lines); and everything in the *Aesthetics* section at the end of Exercise Sheet 2. Please remember that these 30 marks are awarded for producing a high quality professional-looking document!

There is a formal requirement for your document to contain each of the following: a table of contents; a bibliography; referencing using `\ref` and `\cite`; displayed mathematical formulae; and some sort of figure or graphics.

Maths In view of the fact that you'll only have 6 weeks to write the project, and that you'll need to spend quite a lot of time on Maple programming, the mathematical content of your project shouldn't be too ambitious. It's reasonable for your supervisor to expect you to learn some new maths in order to be able to do the project, but it shouldn't be something that takes a great deal of time to get on top of (a few hours reading and talking to your supervisor is the maximum that should be required). The marks for this component will be awarded for a clear and well-structured description of the mathematics underlying your project and the mathematical significance of your programs, not for the difficulty of the mathematics.

Many students go on to do their later dissertations with their Maple/LaTeX project supervisor, so it makes sense if you can choose the topic of your project so that it provides a gentle introduction to the more advanced dissertation work you'll be doing later on.

General This is one of 4 modules you're taking, so the project should occupy about a quarter of your time (10 hours a week?) for the final six weeks of the semester. Don't spend so much time on it that you neglect your other modules. A typical length for Maple/LaTeX projects is between 15 and 30 pages (including program listings), although some students do write up to 50 or 60 pages... It's perfectly possible to get a good distinction-level mark with a 20 to 25 page project.

2 List of Projects and Supervisors

You should aim to be ready to start work on your project by the start of week 7 at the latest, so you should certainly talk to any potential supervisors before that. On the other hand, it may make sense to wait until you have a bit of experience of Maple programming before you make a final decision about your project. Please note

- You should ask the relevant staff members for more detailed descriptions than are given here of the projects they offer.
- All lecturers are eligible for supervising a Maple/LaTeX project, whether or not they're listed here. Feel free to approach anyone whom you think may be able to offer you a suitable project.
- Lecturers may be happy to negotiate a project different from the one they've put on this list.
- There's a general rule that each lecturer shouldn't supervise more than one student's Maple/LaTeX project.
- **Once you've settled on a supervisor, please email me with the supervisor's name. If I haven't heard from you by early in week 7, I'll start rushing about getting worried.**

2.1 Applied Mathematics

Dr. Bearon (404) Models for swimming bacteria searching for food (bacterial chemotaxis).

Professor Biktashev (415A) Autowaves in the Complex Ginzburg-Landau Equation.

Professor Bowers (426) Models in population dynamics or evolution. (One possibility is the application to disease.)

Professor K. Chen (414) Nonlinear mathematical models and numerical algorithms for image processing.

Dr. Guenneau (424) Analysis of stop band properties of arrays of chains and masses. Application to the London Millenium bridge.

Dr. Lewis (419) Solutions of the Schrodinger electronic equation for the hydrogen molecular ion.

Dr. N. Movchan (420) Asymptotic algorithms for elliptic boundary value problems in thin domains **or** The Rayleigh method for spectral problems in periodic domains.

Professor A. Movchan (415B) The dipole tensors for defects in elasticity and electrostatics **or** Homogenization problems for dilute structures.

Dr. Piliposyan (406) Production and transport of natural radionuclides in the atmosphere.

Dr. Selsil (412) Rotation of rigid bodies.

Dr. Vasiev (413) Formation of stationary patterns in reaction-diffusion systems.
Description: In a simplest case this will be about numerical integration of partial differential equations (FitzHugh-Nagumo model) to get any solution which comes first. This could be followed by an investigation of transition between different solutions.

2.2 Pure Mathematics

Dr. Eckl (Room 522) Visualization of plane foliations around singularities.
Description: Plane foliations are made up of the integral curves of partial differential equations in two variables, such as $y\,dx - x\,dy = 0$. In some points these integral curves degenerate to points which are called "singularities" of the foliation (the origin in the example above).

The aim of this project is to write a tool for visualizing the integral curves around such singularities. Furthermore some conclusions on the behaviour of such integral curves can be drawn from observing the pictures obtained by the tool.

Professor Goryunov (519) Quotients of braid groups.

Dr. Guletskii (512) Torsion points on elliptic curves **or** Cubic hypersurfaces of low dimension.

Dr. Hall (521A) Dynnikov coordinates for integral laminations **or** Time profiles and Feigenbaum diagrams for unimodal maps.

Dr. Nair (504) An algorithm in algebraic number theory.

Professor Nikulin (517) Reflection groups of hyperbolic lattices and hyperbolic root systems **or** Riemann surfaces and the Riemann-Roch theorem.

Dr. Pratoussevitch (503) Computations with Gaussian numbers and applications to number theory **or** Cassini ovals **or** Lissajoux curves.

Professor Pukhlikov (521) Desingularization of plane curves.
Description: In order to parametrize plane curves near singular points, one needs to modify the curves via some quite simple and natural maps that are called blow ups. There is a classical algorithm of desingularization that determines how to modify the curve using its Taylor expansion near a singular point. The aim of the project is to realize this algorithm for some singular curves and compute the first Taylor components of their parametrizations.

Professor Rees (515) Various projects on surface topology or complex dynamics.

Dr. Woolf (518) Visualising monodromy for plane algebraic curves.

Description: Investigate the topology of plane algebraic curves (i.e. the zero loci of polynomials $f(x, y)$ of two complex variables) by plotting solutions of $f(x, y) = 0$ as one of the variables follows a closed path in the complex plane.

Professor Zakalyukin (520) Drawing equidistants and singularities using Maple.

Description: 1. Draw ellipse on the plane, given by parametric equations $x = \cos t$, $y = 2 \sin t$. 2. Deduce parametric equation of the normal line to the ellipse at a given point. 3. Plot the e-equidistants of the ellipse for $e = 0.3$, $e = 0.1$. 4. Locate singular points on them, marking them out on the picture. Then, using LaTeX, write down a description of the work done in AMS paper format, including pictures.

2.3 Statistics and Probability

Professor A. Chen (Room 207) Simulation technique in financial modelling.

Description: Binomial and Black-Scholes models are the most simple yet very important models in financial modelling. In this project, the student(s) should apply their knowledge learned from the module MATH 549 and some undergraduate modules to financial problems. In particular, the student(s) should use Maple to simulate the movement behaviour of the stock, say, and then understand the basic principles in pricing American and European options. Knowledge in understanding some basic concepts in finance (particularly stocks, options and forward contracts etc) and binomial models and/or Black-Scholes models will be provided gradually during the process of carrying on this project. (Some relevant modules: MATH 262, MATH 461, MATH 464.)

Dr. Clancy (220) Stochastic modelling of infectious disease spread.

Dr. Gashi (203) Markets with uncertain parameters.

Description: The basic problems in mathematical finance, such as the exploitation of arbitrage opportunities, pricing and hedging of derivatives, and optimal investment and consumption, are well understood when an accurate model of the market is available. A more realistic market model is when all we know about the parameters of the asset prices is that they take values within a certain interval or have a different type of uncertainty. The study of various different problems within this setting is the purpose of this project. This will involve the study of a known technique, its extension to the new setting, and illustrating the obtained results via simulations. (Some relevant undergraduate modules: MATH262, MATH268, MATH304)

Dr. Liu (219) Stability of stochastic differential equations.

Dr. Piunovskiy (206) Study of teletraffic processes: either theoretical investigation, or computer simulation of typical mathematical models of information transmission.

Dr. Zychaluk (216) Performance of different kernels in non-parametric estimation.