DEPARTMENT OF MATHEMATICS
MATHS 761: Ordinary Differential Equations and Dynamical Systems

Notes for Laboratory 1: Using the software package XPP in the computer laboratory

1 Introduction

- In this course we make use of the software package XPP (also known as XPPAUT). XPPAUT stands for 'X-Windows Phase Plane plus AUTO'. XPP can do phase space analysis, continue solutions when varying parameters, and many other things. This package is maintained by Prof. Bard Ermentrout at the University of Pittsburgh. Information about the software, useful tutorials, and the software itself is available at

  `http://www.math.pitt.edu/~bard/xpp/xpp.html`

- **You are expected to visit the website and read the online documentation.**
- The software is free and you can install it on your home computer if you want. XPP is available in the Mathematics Department Basement Computer Laboratory and the Basement Tutorial Laboratory. All Maths students have an account in these labs.
- Make sure you know your NetAccount login and password **before you come to the first laboratory session**. If you are unsure, try out your account **before** the first laboratory session.
- The laboratory sessions for Maths 761 will be held in BTL. XPP can also be accessed in GCL and BCL. General information about the Computer Laboratories can be obtained from:
  `http://www.scl.ec.auckland.ac.nz/city_help.php?h=9`

The rest of this tutorial sheet gives you outlined steps on how to get started with XPP. If you are unsure of how to do any of these things, detailed instructions can be found on the handout 'Hints for Laboratory 1'.

2 Getting started with XPP

You are going to use XPP to draw phase portraits of the equations:

$$\frac{dx}{dt} = x^2 - a,$$
$$\frac{dy}{dt} = -y.$$

1. Login using your usual NetAccount login and password.
2. It's probably a good idea to create a new folder for the work you will do with XPP.
3. Create a text file called 'quadratic.ode' which contains the differential equations you want to investigate with XPP. The contents of the file should be:

```
# quadratic two-dimensional ODE
dx/dt=x^2-a
dy/dt=-y
par a=1
init x=0,y=1
done
```

4. Some information on the syntax of the file:
   - The `#` symbol is a comment. Anything on that line is ignored by XPP.
   - The lines starting `dx/dt` and `dy/dt` specify the differential equations.
   - The line starting with `par` tells XPP that a is a paramter, and specifies the default values of the parameter; in this case setting $a = 1$.
   - The `init` line specifies the default initial values of x and y.
   - It is important that you do not type any spaces on either side of the `=` signs.
   - The last line **must** say `done`.

   More information on the structure of .ode files can be found at
   `http://www.math.pitt.edu/~bard/xpp/help/xppodes.html`
5. Before starting XPP you also need to start an X-Win32 session.
6. Now start XPP. If everything is working correctly a small window with 'Select an ODE file' at the top will appear.
7. You now need to tell XPP which equations to use. Open your file `quadratic.ode`. You should now see a new window with the title 'XPP Ver 5.98 >>quadratic.ode'. If you can see this, you are successfully running XPP. If you cannot see this, ask for help.

3 Running XPP

When you try to tasks listed below, you will notice that the XPP interface is somewhat quirky, but you will get used to that. Some hints:

- In menus you can press the capital letter of the menu item instead of using the mouse.
- Right clicking in a graphics window lets XPP show you the coordinates of the mouse cursor within the window.
- The general escape key is 'Esc' and if this key does not work during numerical calculations you can try the slash key ('/').
- The Tab key does not do what you expect.
- Input box editing is limited to Backspace, Delete, Home, End, Left and Right.

4 Tasks for Laboratory 1

If you have started XPP correctly as outlined above, you will see a window on your screen entitled 'XPP Ver 5.9 >> quadratic.ode' in which you can see an empty X vs T graph. Make sure you can see this window before going on from here.

In the remainder of the first laboratory session, work through as many of the tasks below as possible so that you become familiar with XPP. Make sure you know how to do everything on the list before you come to the second Laboratory session.

You are encouraged to play around with XPP; don't be afraid to open the menus to see what can be done. The handout 'Hints for Laboratory 1' has instructions on how to do each of these tasks if you get stuck.

1. Set up the main window so it shows y vs x (instead of the default x vs t).
2. Integrate the equations, using a variety of initial conditions.
3. See if you can work out how to plot solutions with time running backwards.
4. Change the value of the parameter a and plot some more solutions.
5. Zoom in on some of your solution curves.
6. Now set the parameter a back to 1. Use XPP to find the equilibrium solutions. (It is easy to calculate by hand that they are at $x = -1, y = 0$ and $x = 1, y = 0$.)
7. Draw a phase portrait for the system above, including a representative sample of trajectories and both equilibria, and print it.
8. Play around with XPP to see what else it can do. For instance, try to change the stepsize for the numerical method used to integrate the equations. Which numerical method is used?
9. Quit XPP, and log off the computer.