

# XPPAUT Tutorial for Math 865L

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April 20, 2010

XPPAUT is a software with a graphic interface for solving and analysis ODEs. Here we give the instruction to the basic command.

1. Connection to math account: `ssh -Y account_name@compute.math.ohio-state.edu` It will ask for password for permission.
2. To start XPPAUT: `[account_name@compute ~]$ xppaut Math865L_example1.ode`

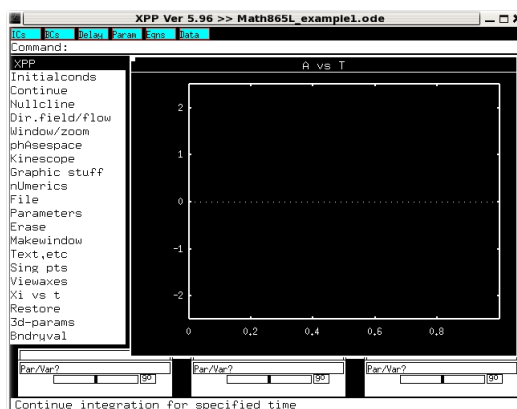


Figure 1: xppaut

Math865L\_example1.ode is a script for XPPAUT to solve the example (3.3)

$$\frac{d}{dt} \begin{bmatrix} [A] \\ [B] \\ [C] \end{bmatrix} = \begin{bmatrix} -1 & 1 \\ -2 & 2 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

where  $v_1 = k_1[A][B]^2$  and  $v_2 = k_2[C]$  which is the model for



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**Algorithm 1** Math865L\_example1.ode

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# Math865L_example1.ode (XPPAUT file) written by Chiu-Yen Kao
# This is an XPP file to numerically integrate the equations in p.19 # in the
first handout : Ch3 Mathematical and computational modeling tools
# SYSTEM OF EQUATIONS
dA/dt = -k1*A*B^2+k2*C
dB/dt = -2*k1*A*B^2+2*k2*C
dC/dt = k1*A*B^2-k2*C
# PARAMETERS
parameter k1=0.5
parameter k2=0.3
# INITIAL CONDITIONS
init A=2.0,B=1.5, C=1.0
# CHANGES FROM XPP'S DEFAULT VALUES
@ TOTAL=1.0,DT=0.01,XLO=0.0,XHI=1.0,YLO=-2.5,YHI=2.5
done
```

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3. To quit XPPAUT, click on File and then Quit
4. To solve with parameters listed in Math865L\_example.ode by XPPAUT, click on Initialconds, and then Go (IG on the keyboard). Notice that only A is plotted!!

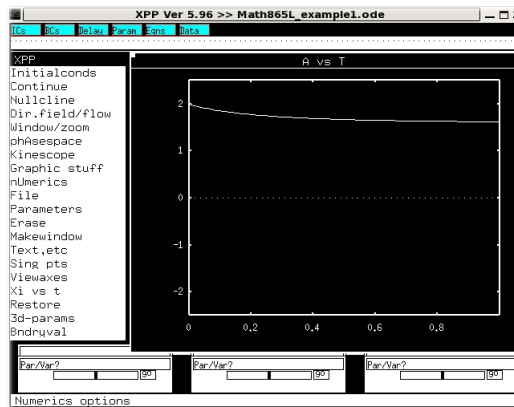


Figure 2:  $A$  v.s.  $t$  for  $0 \leq t \leq 1$

5. To continue the solution from where it ended up by clicking on Initialconds and then Last. It will overlapped with previous plot!! To clear the graphing window, click on Erase.

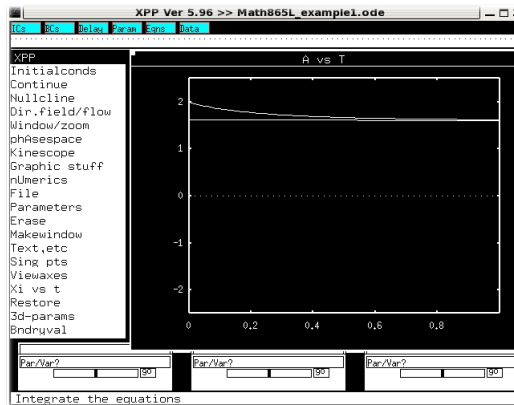


Figure 3:  $A$  v.s.  $t$  for  $0 \leq t \leq 1$  and  $1 \leq t \leq 2$

6. To add a graph, click on Graphic stuff-Add curve. Fill in the popup window with the appropriate information (replace  $A$  by  $B$  on the y-axis; choose color=3 instead of 0).

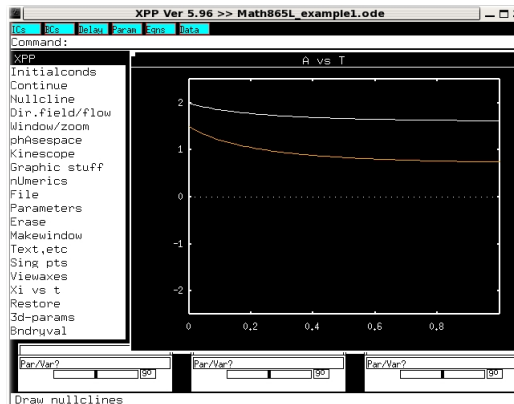


Figure 4:  $A$  and  $B$  v.s.  $t$  for  $0 \leq t \leq 1$

7. To plot  $A$  in a separate window, click Makewindow- Create (MC on the keyboard). You should get a new window with a plot of  $A$ (if you don't see the trajectory, click Restore). To change to a plot of  $C$ , click Xi vs t, and fill in the information asked for in the top bar on the main window (replace  $A$  with  $C$ ). The axes will be scaled automatically. To get different scales, experiment with the Window/zoom command and the Viewaxes-2D command.

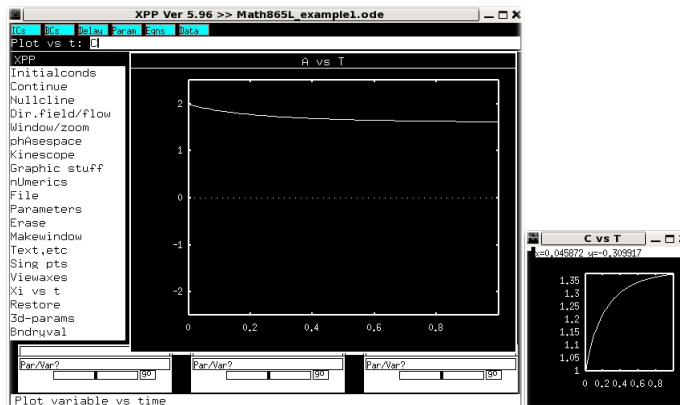


Figure 5:  $A$  and  $C$  v.s.  $t$  for  $0 \leq t \leq 1$

8. How to switch between different windows? The active window is the one that has a tiny white square in the top-left corner of the graphing area. You can make a non-active window active by clicking on its graphing area.

9. Phase-plane analysis: Use the Viewaxes-2D command, and fill in the popup window with the appropriate information. Specify the  $A$  variable on the x-axis, and the  $B$  variable on the y-axis. Also you can adjust the size here.

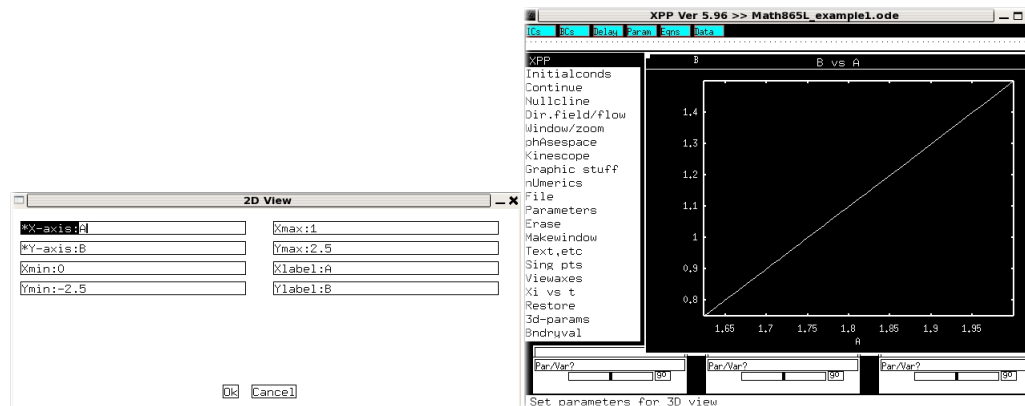


Figure 6: Viewaxes-2D command, phase plan  $A$  and  $B$

10 Click Data on the top to see the data set.

Now Let's go back to the six possible phase portraits listed in Figure 3.3 in the handout. We consider

$$\frac{d}{dt}X = \frac{d}{dt} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} m_{11} & m_{12} \\ m_{21} & m_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = MX$$

where  $M$  is

$$\begin{aligned}
 (a)M &= \begin{bmatrix} 5 & -1 \\ 3 & 1 \end{bmatrix} && \text{node,} && \text{unstable} \\
 (b)M &= \begin{bmatrix} -1 & -1 \\ 0 & -0.25 \end{bmatrix} && \text{node,} && \text{asymptotically stable} \\
 (c)M &= \begin{bmatrix} 3 & -2 \\ 2 & -2 \end{bmatrix} && \text{saddle point,} && \text{unstable} \\
 (d)M &= \begin{bmatrix} 2 & -5/2 \\ 9/5 & -1 \end{bmatrix} && \text{sprial point,} && \text{unstable} \\
 (e)M &= \begin{bmatrix} 1 & -5 \\ 1 & -3 \end{bmatrix} && \text{sprial point,} && \text{asymptotically stable} \\
 (f)M &= \begin{bmatrix} 1 & 2 \\ -5 & -1 \end{bmatrix} && \text{center} && \text{stable}
 \end{aligned}$$

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**Algorithm 2** Math865L\_example2.ode

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# Math865L_example2.ode (XPPAUT file) written by Chiu-Yen Kao
# This is an XPP file to numerically integrate the equations in p.25 # in the
first handout : Ch3 Mathematical and computational modeling tools
# SYSTEM OF EQUATIONS
dx1/dt = m11*x1+m12*x2 dx2/dt = m21*x1+m22*x2
# PARAMETERS
parameter m11=-1 parameter m12=-1 parameter m21=0 parameter m22=-0.25
# INITIAL CONDITIONS
init x1=1.0,x2=1.0
# CHANGES FROM XPP'S DEFAULT VALUES
@ TOTAL=20.0,DT=0.01,XLO=0.0,XHI=20.0,YLO=-2.5,YHI=2.5
done

```

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11 To add the nullclines, click Nullcline-New.

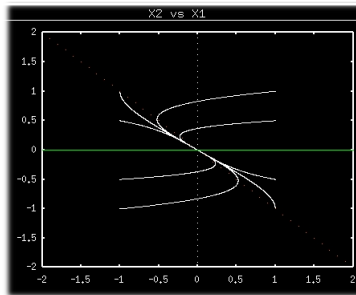


Figure 7: possible Phase Portraits (b)