Temple 8024 **Numerical Differential Equations II** **Fall 2010**

Problem Set 2

(Out Thu 09/23/2010, Due Thu 10/07/2010)

Problem 3

There is an amazing free software package to solve hyperbolic conservation laws with high accuracy: CLAWPACK, by Randall LeVeque and collaborators. It is extremely useful to know. Therefore, with this homework, I force you to install it and learn how to use it, so that you are not afraid of it when you may need it in the future.

(1) Download CLAWPACK Version 4.5.0 from the website `www.clawpack.org` . In the online form, please let the authors know your university, that you are a student, and that your professor uses CLAWPACK for a class on numerical methods.

(2) Copy the file onto a Unix/Linux or Mac OS system, or use Cygwin under Windows. Unpack the file using `tar -zxf` .

(3) Make sure that you have `gfortran`, `python` and `python-matplotlib` installed.

(4) Follow the installation instructions on
`http://kingkong.amath.washington.edu/clawpack/users/installing.html` .
Specifically, set the required environment variables.

(5) Run the example in `apps/advection/1d/example1` by calling `make .plots` . Find out and report which equation is solved with which numerical scheme, and which parameters (T, h, k, limiter, etc.) are used. Plot the result at the final time T.

(6) Change the order of the scheme used (in `setrun.py`), apply the change (calling `python setrun.py`), and re-run (calling `make .plots`) . Again, show the result at the final time T, and explain the difference to the image produced before.

Problem 4

Now we would like to (computationally) reproduce the 2010 tsunami emanating off the coast of Chile.

(1) Run the application in `apps/tsunami/chile2010` (you need to be connected to the internet to download some real data). Which equations are being solved? Explain the meaning of the black rectangles that you can see in the `png` pictures in `apps/tsunami/chile2010/_plots` .

(2) I dislike the low resolution of 30×30. Increase the resolution to 90×90, and re-run the simulation. Print the result at the final time. Rename your folder `_plots` to some other name.

(3) Now change the physics of the earth by reducing gravity by a factor of 9. Re-run the simulation. How does the new result after 9 hours compare with the old result after 3 hours? Which scaling law can you derive from this observation?

Problem 5

Celebrating the recent research results that may explain the Exodus 14:21,27 (google for *"Dynamics of Wind Setdown at Suez and the Eastern Nile Delta"*), we now would like to recreate the parting and returning of the Red Sea.

(1) Start with the application in `book/chap13/collide` which solves the 1D shallow water equations. Why not just run it and look at the results in `book/chap13/collide/_plots` ?

(2) Modify the initial conditions in `qinit.f` to solve *Moses' first problem* with

$$h(x,0) = 1 \qquad \text{and} \qquad u(x,0) = \begin{cases} -0.88 & \text{for } x < 0 \\ 0.88 & \text{for } x \geq 0 \end{cases}$$

and run the computation using `make .plots` . Print the height and velocity field at $t = 2$. Explain what happens.

(3) Now set the initial conditions to solve *Moses' second problem* with

$$h(x,0) = \begin{cases} 1 & \text{for } x \leq -2 \\ 0.01 & \text{for } -2 < x < 2 \\ 1 & \text{for } x \geq 2 \end{cases} \qquad \text{and} \qquad u(x,0) = 0$$

and run the computation. Print the height and velocity field at $t = 4$. Explain what happens.