PHYS 210: Introduction to Computational Physics Fall 2013 Homework 1
Due: Thursday, September 26, 11:59 PM

PLEASE report all bug reports, comments, gripes etc. to Matt: `choptuik@physics.ubc.ca`

Please make careful note of the following information and instructions, which will generally apply to subsequent homeworks as well:

1. There are 5 problems in this homework, most of which have multiple parts.
2. Please do *not* be put off / terrified etc. by the length of this homework handout, including this preamble. As previous students of my computational physics courses can attest, I tend to spell things out in gory detail, so there really isn't as much work to do as it might seem.
3. As we will discuss in the second lab, I have created directories for all of you of the form `/phys210/$LOGNAME`, where `$LOGNAME` is the name of your PHAS account.
4. Within `/phys210/$LOGNAME`, I have also created sub-directories `hw1, hw2, hw3` and `hw4` which you will use to complete the four homework assignments in this course. In particular, for this assignment, you will create various directories and files that will need to reside within `/phys210/$LOGNAME/hw1`, and any reference to directory `hw1` below is implicitly a reference to `/phys210/$LOGNAME/hw1`.
5. The `hw[1-4]` sub-directories are *read, write and execute* protected from other users. *Please do NOT change the permissions on those sub-directories. This will ensure that none of your fellow students—or anyone else except myself and the TAs—can access your homework.*
6. Follow the instructions that accompany every question very carefully. Attention to detail is an important aspect of computational science, as is the ability to work precisely to specifications. Pay special attention to the name of files that you are to create, and to the ultimate locations (i.e. directories) in which they are to reside.
7. At least for this assignment you should be prepared to do your work using the lab machines. If you have Linux or a `ssh`-client installed on one of your own machines (or are able to get either/both installed in time), then you may be able to complete some of the work outside of the lab.
8. As you complete this homework, you will need to access (and perhaps make copies of) various files/directories that reside in the account `phys210` on the lab machines. Recall that `~phys210` is a reference to the home directory for `phys210`, and you should have the appropriate access (permissions) for any of the needed files/directories. Let me know ASAP if you find that this is not the case.
9. Your grade *may* be adversely affected if you do not strictly follow the above instructions, in addition to those given in the individual problems below: we will be willing to give you a little leeway at the beginning of the course, but will tend to be less and less forgiving as time goes on!
10. Note that the marking scheme (i.e. how much each question is worth) has purposefully *not* been included here. This homework will give the TAs and myself vital information concerning what we should expect from the class as a whole, and I don't want to unnecessarily discourage anyone at this stage. This means, for example, that questions that seem to you to be more difficult than others will not necessarily be worth more.
11. **IMPORTANT!!** Immediately following the deadline for this assignment, the contents of your homework directories will be copied to another location for grading. *This means that any files added/modified* after *the deadline will* not *be those that are graded*. This remark applies to subsequent assignments as well.
12. **IMPORTANT!!** Feel free to contact me (choptuik@physics.ubc.ca) *immediately* should you have any questions about these instructions, or if you are having undue difficulty with any part of the homework. And again, you are free to seek help during the lab sessions from both the TAs and myself, as well as from myself during my official office hours (2:00-3:00 PM, Mon & Wed), or on a drop-in/appointment basis. Bear in mind though, that as much as possible, we of course want to encourage you to "think and do for yourself"!

Problem 1a:
In your `hw1` directory (i.e. `/phys210/$LOGNAME/hw1`), create a sub-directory `a1` (i.e. `/phys210/$LOGNAME/hw1/a1`). In that directory (`hw1/a1`), and using the Unix/Linux text-editor that you have chosen from the list discussed in class (i.e. `gedit`, `gvim`, `xemacs`, `vi/vim` or `emacs`), create a file named `apple` that contains the following text from *Gravitation*, by Misner, Thorne and Wheeler. Try to duplicate the spacing, line breaks, punctuation etc. as closely as possible.

```
Once upon a time a student lay in a garden under an apple tree reflecting
on the difference between Einstein's and Newton's views about
gravity.  He was startled by the fall of an apple nearby.  As he
looked at the apple, he noticed ants beginning to run along its
surface. His curiousity aroused, he thought to investigate the
principles of navigation followed by an ant.  With his magnifying glass,
he noted one track carefully, and, taking his knife, made a cut in the apple
skin one mm above the track and another cut one mm below it.  He peeled
off the resulting little highway of skin and laid it out on the face
of his book.  The track ran as straight as a laser beam along this
highway.  No more economical path could the ant have found to cover
the ten cm from start to end of that strip of skin.  Any zigs and
zags or even any smooth bend in the path on its way along the apple
peel from starting point to end point would have increased its length.

   ``What a beautiful geodesic'', the student commented.
```

Problem 1b: Create a file in the same directory (`hw1/a1`), called `kumquat` that is identical to `apple` except that all occurrences of the word "apple" are replaced with "kumquat". Leave a brief note in a file called `README` (again in the same directory) that describes how you created `kumquat` (including which editor that you have used) and how you made the changes.

Problem 2: I have created directories for each of you that you may use to "publish" Web pages (related to this course) via my research group's web server (`http://laplace.physics.ubc.ca`). Your personal Web directory on the server (which I'll subsequently refer to simply as your Web directory) is `/phys210/$LOGNAME/public_html`, and in that directory you will find a text file `index.html` which currently should contain the name of your account (i.e. the text `$LOGNAME`, and nothing else).

I have also created a "template" homepage in `/phys210/phys210/public_html/index.html`, and which you can view using a browser by going to `http://laplace.physics.ubc.ca/Students/phys210/`.

To complete the problem, do the following:

- Copy this template `.html` file into your Web directory (use the same name—`index.html`—so you will overwrite the existing `index.html`) and modify it to reflect your name, academic address (or home address if you so wish), phone-number etc. You can use a Web authoring tool (such as the `composer` component of the `seamonkey` browser), or should you want to write the HTML "by hand", use your text editor of choice. If you want to pursue the latter option, then you may find the information accessible through the *Web Authoring* section of the *Online Course Resources* page to be of use. If you don't feel like publishing any specific piece of information, specify it as "unlisted". Below the horizontal rule (line) in the template file, delete the existing text, and add suitably labelled links to (a) the course home page and (b) the instructor's home page.
- Now, choose a topic in physics or astronomy of current/ongoing interest and insert a one or two paragraph summary of it below the links. You can find a list of suggested topics at

  `http://laplace.physics.ubc.ca/210/hw1/`

  (which you can also access via the course homework page). You are, however, free to choose your own subject but, again, it should be something topical in the realms of physics or astronomy. Cite your sources, providing links to online material where possible.
- In addition, below your synopsis, provide at least 5 links (in addition to any citation links) to supplementary information on the topic. Preface this content with the heading: `Supplementary Information`.
- Finally, check your work by verifying that you can view your creation by directing your browser to our main course page, selecting *Student Pages* and then your name. Also, please send me e-mail should the way I have listed your name in the *Student Pages* list need changing.

Problem 3: Make the directory `hw1/a3`. From the system file `/usr/share/dict/words` that we discussed in class, I have created the file ∼`phys210/hw1/prob3/words`. This file, hereafter referred to simply as `words`, contains a list of "words" (mostly genuine English words—for the purposes of this question, any entry in the file will be deemed a "word"), one per line. Also, note that "alphabetical" below means "in the same order as the entries appear in the file".

1. How many words does `words` contain? Provide your answer and a precise description of how you determined it in the file `hw1/a3/README`. (You will need to create this file—with your text editor—as well as the other `README`'s that are referenced in subsequent problems. Please ensure that the filename is literally `README`, i.e. all upper case.)

In `hw1/a3` create files with names and contents per the list below (words should appear one per line).

Use only the basic features of `grep` described in the Unix notes (i.e. don't use any of the extended features that are available in some versions of `grep`, including the one on the lab machines).

Also note that some of the sub-questions below can be solved with a single `grep` command. For others, it may be useful to consider using a pipeline.

In all cases, document precisely how you solved the problem in `hw1/a3/README`.

2. `22letter` which contains, in alphabetical order, all the twenty-two-character (twenty-two-letter) words in `words`.
3. `6letter` which contains, in alphabetical order, all the six-character words in `words` that begin with 'e' or 'E', and end with 'y' or 'x'.
4. `r4letter` which contains, in *reverse* alphabetical order, all the four-character words in `words`. (*Hint: Use the Unix/Linux* `sort` *command: as usual, type* `man sort` *to get detailed usage information).*
5. `3cons` which contains, in alphabetical order, all the words in `words` which contain three or more consonants in a row (lower or upper case), and which do *not* contain two or more vowels in a row (lower or upper case): `yacht` is one such word. Define the set of vowels to be 'a','e', 'i', 'o' and 'u', and the set of consonants to be any character which is not a vowel.
6. `phas-8-12` which contains, in alphabetical order, all words in `words` which are between 8 and 12 characters, inclusive, in length, and which contain all four of the characters 'p', 'h', 'a' and 's'. Any of these four characters may occur more than once, can appear in the word in any order, but all must be lowercase.

In completing this problem, you may find it convenient to copy `words` to your solution directory, and you should feel free to do so.

Problem 4: The `Fortran` programming language is used extensively for numerically-oriented (scientific) computations. Starting in the 1950's (!) various versions of the language have been developed: one of these is `Fortran 77`.

The file `~phys210/hw1/prob4/code.f` (hereafter referred to simply as `code.f`) contains `Fortran 77` source code and, similarly to the previous problem, this question requires you to use Unix/Linux commands (e.g. `grep`) and constructs (e.g. pipes) to extract various information from the file.

Make the directory `hw1/a4`, and in that directory answer the following. In all cases, use `hw1/a4/README` to document the command(s) that you used in your solutions, as well as to to provide any specific information that is requested.

1. How many lines does `code.f` contain?
2. Programming languages generally define a mechanism by which "comments" can be included in source code: comments are used strictly for documentary purposes, and have no effect on the way that the program (application) derived from the source code executes. In `Fortran 77` any line which begins with a 'c' or 'C' is a comment. Create a file `hw1/a4/comments` which contains all of the comment lines in `code.f` (Here and in subsequent sub-questions the extracted lines must appear in the order in which they occur in the original file). How many comment lines does `code.f` contain?
3. How many "empty" lines does `code.f` contain? Consider a line to be empty if it contains *no* non-blank (space) characters.
4. Create a file `hw1/a4/return` which comprises all lines in `code.f` that contain the string 'return' (case insensitive).
5. Create the file `hw1/a4/return-only` which comprises all lines in `code.f` that contain *only the* string 'return' (case insensitive) and zero or more spaces (blank characters).
6. Any `Fortran 77` statement can be prefixed with a *statement label*. A statement label is a string of 1 to 6 characters, each of which must be a number or a space, and where at least one of the characters is a number. The label must be positioned within the first six columns of the line in which it is defined, and if a statement has a label then *only* numerals and spaces can occupy the first 6 columns.

   For example the statement

   ```
   100         continue
   ```

   has a valid label, while

   ```
   100aa       continue
   ```

   does not, where in each case the '1' is positioned in the first column.

   Create the file `hw1/a4/slabel` that contains all lines in `code.f` that define a statement label.

Again, in completing this problem, you may find it convenient to copy `code.f` to your solution directory.

Problem 5: Make the directory `hw1/a5`. Use the plotting program `gnuplot` (available on the lab machines, and installable on any Linux system) to do the following:

1. Generate a plot of $\exp(-4x^2)\sin(12x)$ for $-1 \leq x \leq 1$, with a title for the whole plot:

   `<Your name> HW1, Problem 5-1`

   where `<Your name>` is to be replaced with your name.

   Note that this title should appear above the plot *per se*; in particular, it should not be confused with the title/label/legend associated with the curve itself. The latter will appear within the frame of the plot, and can be left at the value that `gnuplot` sets as a default.

   Once you are satisfied that the plot is correct, save it in JPEG (JPG) format as the (image) file `a5-1.jpg`.

   Once this is done, incorporate the resulting image file in the web page that you created in answering Prob. 2 (insert it *after* the content you included to complete that problem).

2. The file `~phys210/hw1/prob5/data` contains 3 columns of numeric data. Generate a *single* graph that plots:

   (a) The second column versus the first using blue filled squares, and with a title: `raw data`

   (b) The third column versus the first using a red line, and with a title: `fit`

   Give the plot an overall title (as in the previous sub-question):

   `<Your name> HW1, Problem 5-2`

   replacing `<Your name>` with your name, as before.

   Again, once you are satisfied that the plot is correct, save it in JPEG (JPG) format as the image file `a5-2.jpg`, and include the image in your web page from Prob. 2, inserting it below the image from the previous sub-question.

   In completing this part of the problem, you may find it convenient to copy `~phys210/hw1/prob5/data` to your solution directory.

Note that you can view the image files (JPEG files) that you create using the command `imview`, e.g.

```
% imview a5-1.jpg
```

or by clicking on the file's icon from within the Home Directory application of the Ubuntu desktop (which simply invokes `imview` with the name of the selected file as an argument).

Hint: Use `gnuplot`'s extensive on-line help: you may find `help plot`, `help set`, `help terminal`, `help output` and `help test` especially useful. There is also reference and tutorial material on `gnuplot` available via the *Graphing (XY plots)* section of the *Online Course Resources* web page, and, of course, you can make use of search engines to retrieve an abundance of `gnuplot` lore.