PHYS 210: Introduction to Computational Physics Fall 2014
Homework 1: Version 6—September 23, 2014—Problem 2, item 6 description amended.
Due: Thursday, September 25, 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, much of which will also apply to subsequent assignments.

1. There are 5 problems in this homework, most of which have multiple parts.
2. Problems marked with ($\star$) may be particularly challenging, so don't be surprised if it takes you longer to figure out solutions for them than the others.
3. Please do *not* be put off / terrified etc. by the length of the 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.
4. As discussed in the lab, I have created directories for all of you of the form `/phys210/$LOGNAME`, where `$LOGNAME` is the name of your PHAS account.
5. Within `/phys210/$LOGNAME`, I have also created sub-directories `hw1, hw2` and `hw3`, which you will use to complete the three homework assignments in this course. In particular, for this assignment, you will create various directories and files that will need to reside within `/phys210/$LOGNAME/hw1`, and any reference to directory `hw1` below is implicitly a reference to the absolute pathname `/phys210/$LOGNAME/hw1`.
6. The `hw[1-3]` 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.*
7. 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. For your convenience, at the end of each question there is an inventory of the files that are required. Your solution may contain additional files that you created, copied etc. during the course of your work: i.e. you don't need to worry about cleaning up your solution directories.
8. At least for this assignment you should be prepared to do your work using the lab machines. However, provided that you have a Mac, or are running Linux on one of your machines, or are using Windows and have `PuTTY` (or some other `ssh` client) and `Xming` installed (see the course *Software* page), you should be able to do much of the assignment remotely.
9. **Important!** *Added September 11:* If you *are* working remotely using `PuTTY`/`Xming` or a Mac, I suggest that you use the text editor `gedit`, which, like `kate`, can be invoke from the command line. e.g.

   ```
   % gedit somefile
   ```

   `gedit` is the default editor for GNOME, the other major desktop in the Linux world (we are using KDE in the lab). It appears to have much better performance than `kate` when used remotely and is a perfectly good text editor for the purposes of this course.
10. 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.

— *Instructions continue on flip-side.* —

11. 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! Non-adherence to the instructions means more grading effort for the TAs, and, for obvious reasons, you don't want them to be irritated while they are marking your work.

12. Note that the marking scheme (i.e. how much each question is worth) has purposely *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.

13. **IMPORTANT!!** Please read carefully the *Homework & Term Paper Policy / Academic Misconduct* section of the course *Homework* page, and please abide by that policy, particularly with regards to collaboration with fellow students.

14. **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. Note that other than the directories/files specified below, there is nothing to hand in.

15. **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 myself and the TAs, 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 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 `kate`, `gnome` (better if working remotely) or any other Linux text editor you wish, 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. Note that you do *not* have to use a Linux/Unix command other than the editor to make the changes.

You will need to create `README`—as well as the other `README`'s that are referenced in subsequent problems—using your text editor of choice. Please ensure that here and in the other instances the filename is literally `README` (i.e. all upper case).

File inventory: All file references are relative to `a1`

1. `apple`
2. `kumquat`
3. `README`

Problem 2:

As discussed in one of the labs, 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 that directory should currently contain, among other things, the text file `index.html` that we modified in the lab using the `composer` component of `seamonkey`. Should you wish to save the contents of that file before proceeding with this problem, give it a new name using, e.g.

```
% cd /phys210/$LOGNAME/public_html
% mv index.html index.html.0
```

I have also created the text for a "template" homepage in `/phys210/phys210/public_html/index.html` which you can view by pointing your browser to `http://laplace.physics.ubc.ca/Students/phys210/`.

1. Copy the template

   `/phys210/phys210/public_html/index.html`

   to your web directory (use the same name—`index.html`—so you will overwrite the existing `index.html` if you haven't renamed it as above) 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 `composer`—to edit the web page or, should you want to write the HTML "by hand", using your text editor. 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 want to publish any specific piece of information (including your name, presumably, if you haven't given me permission to list your name on the Student page), then 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.

2. Now, choose a topic in physics or astronomy of current/ongoing interest and insert a short summary of it below the links: two or three paragraphs will suffice, although you can make it longer should you wish. 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 as long as it is something topical in the realms of physics or astronomy. Cite your sources, providing links to online material where possible.

3. **Important!** *The summary must be written in your own words.*

4. 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* (you don't have to use italic font).

— Problem description continues on next page —

5. Choose four of your favorite scientists—physicists and/or astronomers if you prefer, but not necessarily. If you don't have at least four favorites, now's the time to accrue some.

   Below the *Supplementary Information* section create a table with 2 columns and 2 rows and insert images of the four folks you've chosen in the 4 cells of the table (i.e. each distinct cell will have an image of one distinct person). If you use `composer`, or some other web authoring app that requires it, use the name of the appropriate scientist for the *Alternate text* associated with each image.

   Clearly it will help if it is easy to find images on the web for the people that you choose.

   Note that as illustrated in the lab it is best if you copy the images into your `public_html` directory and then link the copies into your HTML code. *Hint:* To download/copy an image, position the mouse pointer over it, bring up a menu (usually the right mouse button), then use the *Save Image As ...* function to save a copy in your web directory.

   Below the table provide a legend of the form:

   ```
   Four of my Favorite Scientists

   Clockwise from top left

   1. Leslie Winkle (image credit: <cite source of image as as possible>)
   2. Leonard Hofstadter (image credit: <cite source of image as as possible>)
   3. Amy Farrah Fowler (image credit: <cite source of image as as possible>)
   4. Sheldon Cooper (image credit: <cite source of image as as possible>)
   ```

   Just to be clear <cite source of image as as possible> is another example of "meta-notation", i.e. the entire "meta-expression", including the < and > delimiters is to be replaced with a specific citation. E.g.

   ```
   1. Leslie Winkle (image credit: Leonard Hofstadter (2012))
   ```

   If you can't determine an appropriate image credit, omit it from the legend. Try to use appropriate HTML elements (i.e. a heading and enumerated list) in your legend and certainly do *not* use a fixed-width font as I have done above!

6. As you work through this problem, periodically check your handiwork by directing your browser to our main course page, selecting *Student Pages* and then your name (or anonymous identified).

   Important! Be sure to check that all of the intended contents of your page—most notably the images—appear when the page is accessed from *outside the lab*, e.g. using a browser on your laptop or home machine. To facilitate this, and as mentioned above, make sure that the image files are located in `/phys210/$LOGNAME/public_html`, *not* somewhere within your home directory, `/home2/$LOGNAME`.

7. Please send me e-mail should you wish to change the way your name in listed in *Student Pages*.

File inventory: All file references are relative to `/phys210/$LOGNAME/public_html`

Your solution may involve more files than the following:

1. `index.html`
2. Image files for your favorite physicists/astronomers.

Problem 3:

Make the directory `hw1/a3`. Using the system "dictionary" file `/usr/share/dict/words` that is mentioned in the Unix notes, 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`.

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

Use only the basic features of `grep` described in the Unix class and lab 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).

Note that all of the characters in `words` are lower case, so you don't have to worry about issues of case in answering this problem.

For questions that refer to vowels and/or consonants, define the set of vowels to be 'a', 'e', 'i', 'o', 'u', 'y' and the set of consonants to be any alphabetical character which is not a vowel.

Finally, 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` (i.e. include the specific command(s) that you used in each case in your documentation).

2. `17letter` which contains, in alphabetical order, all the 17-character (17-letter) words in `words`.
3. `23letter` which contains, in alphabetical order, all the 23-character (23-letter) words in `words`.
4. `r678letter` which contains, in reverse alphabetical order, all the words in `words` that are 6, 7 or 8 characters in length, begin with a vowel and end in 'ing'. (*Hint: Use the Unix/Linux* `sort` *command: as usual, type* `man sort` *to get detailed usage information).*
5. `5letter` which contains, in alphabetical order, all the words in `words` that are 5 or more characters in length, contain 3 or more vowels in a row (can happen more than once), and begin with a consonant. `chorioidocyclitis` and `forhooie` are two such words.
6. `astro-9-16` which contains, in alphabetical order, all words in `words` which are between 9 and 16 characters inclusive in length and which contain all five of the characters 'a', 's', 't', 'r' and 'o'. Any of these five characters may occur more than once and can appear in the word in any order. `arthrosteitis`, `endopericarditis` and `turbosupercharge` are examples of such words.
7. (⋆) `4cons` which contains all of the words in `words` that contain *precisely* 4 consonants (no fewer, no more).

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

File inventory: All file references are relative to `a3`

1. `17letter`
2. `23letter`
3. `r678letter`
4. `5letter`
5. `astro-9-16`
6. `4cons`
7. `README`

Problem 4: ($\star$)

Make the directory `hw1/a4` and in `hw1/a4/README` document how you solved the following subproblems:

Problem 4a:

The directory ∼`phys210/hw1/prob4/a` contains 3556 files.

1. Using a *single command* or a *single pipeline of commands* verify that the directory has that many files in it, and document how you did it in the `README` for this problem.
2. The contents of each file in ∼`phys210/hw1/prob4/a` is a single word. You can verify this for yourself—at least for some subset of the files—by direct examination, or you can take my word for it (no pun intended).

   ($\star$) Make the directory `hw1/a4/a` and, using a *single command* or a *single pipeline of commands*, copy into that directory all the files from ∼`phys210/hw1/prob4/a` whose content is a word that begins with at least two consecutive vowels and ends with at least two consecutive consonants. Define the set of vowels to be 'a', 'e', 'i', 'o', 'u', 'y', 'A', 'E', 'I', 'O', 'U' and 'Y', and the set of consonants to be any character which is not a vowel. Example of words that meet the above criteria are `airposts`, `yalb` and `oinking`.

   Document your command/pipeline in the `README` file for this problem.
3. **Bonus: Strictly optional for some small amount of extra credit:**
   Hypothesize how the instructor created the 3556 files to have their specific content.

Hints:

1. Consider using the `grep` command: there is a specific option to `grep` that we have *not* discussed in the notes/labs that may be useful.
2. Look for hints in the lab notes.

Problem 4b:

The directory ~`phys210/hw1/prob4/b` contains 1186 files, each of which is one of:

1. A Bourne-Again shell script (a.k.a. a bash script).
2. A Perl script (Perl is a scripting language, popular in the Linux world).
3. A Tenex C shell script (the Tenex C shell, or tcsh, is an alternative shell to bash that is also widely used).
4. A Python script (python is another popular scripting language, and one to which you will be exposed in other PHAS courses).

You can use the `file` command, that was briefly demoed in the Unix notes and labs to determine which of the 4 types each file is. For example ...

```
% cd ~phys210/hw1/prob4/b

% file script13
script13: Bourne-Again shell script, ASCII text executable

% file script1138
script1138: Perl script, ASCII text executable

% file script619
script619: Tenex C shell script, ASCII text executable

% file script998
script998: Perl script, ASCII text executable
```

> As an aside, and for your (possible) amusement, note that as the output from the `file` command indicates, each of the files in ~`phys210/hw1/prob4/b` is an *executable*. I.e. each file can be executed as a command simply by typing its name (provided that the working directory is ~`phys210/hw1/prob4/b`). For example:
>
> ```
> % file2810
> Hello! I am a Perl script and my name is file2810.
>
> % file2199
> Hello! I am a Tenex C shell script and my name is file2199.
> ```
>
> You can probably guess what the output from the other 1184 commands is apt to look like. Note that I'm not claiming that these are *useful* commands! End aside.

($\star$) Make the directory `hw1/a4/b` and, using a *single command* or a *single pipeline of commands*, copy into that directory all of the Python scripts in ~`phys210/hw1/prob4/b`.

Document your command/pipeline in the `README` file for this problem.

Hint:

1. Look for hints in the lab notes.

File inventory: Relative to `a4`

1. `README`
2. In subdirectory `a`: A bunch of files.
3. In subdirectory `b`: Another bunch of files.

Problem 5:

Make the directory `hw1/a5`. Use `gnuplot` to do the following:

Problem 5a:

Generate a plot of

$$\left|\cos(2x)\sin(12x) - \frac{1}{2}x^3\right| \qquad \text{for} \quad -1.1 \le x \le 1.1$$

with a title for the whole plot:

```
<Your name> HW1: Problem 5a
```

where `<Your name>` is to be replaced with your name (do *not* include the `<` and `>` symbols).

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.

Ensure that:

1. The limits on the x-axis in the plot coincide with the limits of the domain on which the function is to be plotted.
2. `gnuplot` uses enough data points (i.e. (x, y) pairs) so that the resulting plot does not have visible "artifacts" that are due to insufficient sampling. *Hint:* In `gnuplot` parlance, the key notion is `sample`. Ask the program for `help` with that topic.

Note that gnuplot uses the following syntax for the basic arithmetic operations:

```
+   --  Addition
-   --  Subtraction (and unary minus)
*   --  Multiplication
/   --  Division
**  --  Exponentiation
```

Once you are satisfied that the plot is correct, save it in JPEG format as the (image) file `a5a.jpg`. (Note that `.jpg` is the standard 3-character extension for JPEG files.)

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). As discussed in Prob. 2, you should copy the image file to your `public_html` directory to facilitate its inclusion in the web page.

Document the `gnuplot` commands that you used to produce the plot in `hw1/a5/README`.

Here and in the next sub-problem, and as discussed in the lab, you may want to interact with *gnuplot* using a script (text file of `gnuplot` commands) and the `load` command.

Also note that *gnuplot* maintains a history of the commands that you enter that you can recall and edit using the arrow keys etc. in complete analogy with command-line editing in bash.

Problem 5b:

The file ~`phys210/hw1/prob5/data` contains 5 columns of numeric data. Generate a *single* graph that plots:

1. The third column versus the first using green open squares, and with a title: `raw data`
2. The fifth column versus the first using a blue line, and with a title: `fit`

Make the range of the horizontal axis match that of the data itself.

Since there has been some confusion about this point in the past, note that "plot B versus A" means that the A-axis is horizontal and the B-axis is vertical.

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

```
<Your name> HW1: Problem 5b
```

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

Again, once you are satisfied that the plot is correct, save it in JPEG format as the image file `a5b.jpg`, and incorporate 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 `display` command, e.g.

```
% display a5a.jpg
```

or the `gwenview` command, e.g.

```
% gwenview a5a.jpg
```

or by clicking on the file's icon from the file browser (`dolphin`).

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.

File inventory: All file references are relative to `a5`

1. `a5a.jpg`
2. `a5b.jpg`
3. `/phys210/$LOGNAME/public_html/a5a.jpg` (for purposes of inclusion in your course page)
4. `/phys210/$LOGNAME/public_html/a5b.jpg` (for purposes of inclusion in your course page)
5. `README`