Systems Development for Computational Science
CS107/AC207 Fall 2022

Harvard John A. Paulson School of Engineering and Applied Sciences

F. Wermelinger
Office: SEC 1.312-02

Homework 0

Git, sequences and series, basic calculus

Issued:	August, 2022
Due:	None

This assignment will not be graded. It is provided for you to gauge your prerequisite knowledge for this course. You are not required to turn it in. We recommend that you complete it before the beginning of the semester and no later than after the first week of class. You do not need to be able to solve this problem sheet perfectly in order to take this class.

Problem 1: Git (*30 points*)

The following are a few short questions about the Git version control system (VCS) with some applications.

a) ***10 points***

The following are conceptual questions about the Git VCS.

i) There are many other VCS systems, Apache Subversion (SVN) is one of them. What is the main difference between SVN and Git?

ii) What is the difference between a Git commit and a Git branch?

iii) What is the difference between a local and a bare Git repository?

b) ***10 points***

The following questions are related to how to use Git in practice.

i) Assume you are given the URL `git@code.harvard.edu:CS107/main.git` to a remote Git repository. What is the protocol used to connect to this remote? What is the command to clone this repository locally?

ii) You have two local Git repositories A and B. Assume your command line is in repository A and the path to repository B is `../../B`. Add a new remote for B called `upstream`.

iii) You are in repository A of the previous sub-question and want to inspect the local history. What is the command for this task?

iv) Still inside repository A, you want to create a new branch called "`myfeature`" that is based off the branch `feature` in repository B that you have added as a remote earlier. What is the correct command to obtain this new branch?

c) ***10 points***

The following questions are related to resolving issues with the Git history.

i) Assume you still work in repository A of the previous sub-question. You have committed a file `foo` and a file `bar`. You just realized there is a mistake and you no longer want the commit that added `bar` to the history. You want to recover the state you had just before you created the commit. Your history looks like this

```
$ git log --oneline
7cfb894 (HEAD -> master) Add bar
30e55ad Add foo
```

What is the command to get rid of the top commit and recover the state just before you have created commit `7cfb894`? What is the status of the file `bar` called in that earlier state?

ii) Assume you have pushed the commit `7cfb894` to a remote repository *before* you have applied the operations of the previous sub-question. You now apply some changes, create a new commit and then you push with `git push --force`. Your local and remote history now looks like this

```
$ git log --oneline
10f23e7 (HEAD -> master) Add modified bar
30e55ad Add foo
```

Why did you need to add the `--force` option when you pushed? Do you expect any trouble ahead?

Problem 2: Sequences and Series (*30 points*)

Many mathematical and physical constants can be expressed as infinite sums, infinite products, and limits of recursion relationships. In this problem, we will consider representations for two very famous numbers, π and the golden ratio φ. One way to represent π is with the infinite series

$$\frac{\pi^2}{6} = \sum_{n=1}^{\infty} \frac{1}{n^2}.$$

The golden ratio φ is the positive root of the quadratic equation $x^2 - x - 1 = 0$. It's exact value is $\varphi = \frac{1}{2}(1 + \sqrt{5}) \approx 1.618033$. Interestingly, it can also be expressed as the limit of the ratio of consecutive terms in the Fibonacci sequence. The n-th term of the Fibonacci sequence is given by

$$F_n = F_{n-1} + F_{n-2} \quad n > 2,$$

where $F_1 = F_2 = 1$ are seed values. For example, the ratio $F_7/F_6 = 1.625$.

In this problem, you will write a Python function to compute π and φ from the representations just described.

a) ***16 points***

Write a Python function called `numbers` that uses the infinite series representation to calculate π and the ratio of consecutive Fibonacci numbers to calculate φ. Your function should follow these requirements:

- The function should accept two arguments: A string indicating which number to calculate. The string can be either `pi` or `golden`. The second argument is an integer to specify how many terms to use in the approximation. For example, if the integer is 10, then the first 10 terms of the sum for the number in the first argument will be used.
- Depending on the arguments, the function will calculate either π or φ.
- If the user supplies an unrecognized argument, then the function should fail with an informative error message.
- The function should return a `float` (floating point value) which represents either π or φ.

Hint: *After* 10 *terms you should find* $\pi \approx 3.049362$ *and* $\varphi \approx 1.617647$.

b) ***4 points***

Calculate π and φ using a variety of different terms in the expansion or recursion. Follow these requirements:

- Create a Python list of integers. Each integer represents the number of terms in the series representation or the recursion relation.
- For the π expansion, you should use at least 500 terms.
- For the φ recursion, you should use the integers up to 10.
- Iterate over the list and calculate π and φ for each item.
- Store the results in a new list.

c) ***10 points***

Plot the approximate values of π and φ as a function of the number of terms. Make two separate plots, one for π using a logarithmic scale on the abscissa and one for φ. On each figure, plot the true value of π and φ as a horizontal line.

Hint: *You may use NumPy to get the true value.*

Problem 3: Basic Calculus (*40 points*)

The project for this class will require some basic calculus knowledge. Please review the introductory calculus class materials and try to answer the following questions.

a) ***10 points***

i) Given a function $f(u)$ where $u = u(x)$ is a function of the scalar x, compute the derivative $\frac{\mathrm{d}f}{\mathrm{d}x}$.

ii) Assume $f(u) = \sqrt{u}$ and $u(x) = \sin(x) + 1$, evaluate the derivative $\frac{\mathrm{d}f}{\mathrm{d}x}$.

b) ***10 points***

i) Given a function $f(u, v)$ where $u = u(x)$ and $v = v(x)$ are both functions of the scalar x, compute the derivative $\frac{\mathrm{d}f}{\mathrm{d}x}$.

ii) Assume $f(u, v) = \sqrt{u + v}$, $u(x) = \sin(x)$ and $v(x) = 1$, evaluate the derivative $\frac{\mathrm{d}f}{\mathrm{d}x}$.

c) ***20 points***

i) Compute the derivative of the following polynomials
   1. $2x^2 - x$
   2. $(x - 1)(1 - x^2)$

ii) Compute the derivative of the following trigonometric functions
   1. $\sin(x)$
   2. $\tan(x)$
   3. $\sec(x)$

iii) Compute the derivative of the following exponential functions
   1. e^x
   2. a^x where a is some constant
   3. x^y where x and y are variables

iv) Compute the derivative of the following algebraic functions
   1. $\sqrt{x}$
   2. $\log(x)$