

Homework Assignment #0

Professor: Eric Gerber

Name: _____

Instructions: Please include the following information on the first page of your completed homework write-up:

1. Your name
2. DS 4420
3. Homework #0

You will submit **up to four files** to Gradescope for this homework:

- A **.pdf** file with handwritten/latex typeset answers to the math problems
- A **.ipynb** file with all python code/output
- A **.html/.pdf** file knitted from an included **.rmd** with all R code/output
 - **Note:** on future assignments, only **.pdf** files will be accepted (not **.html**). You may still knit to **.html** and then, after opening in your browser, use **ctrl + p** (windows) or **cmd + p** (mac) to convert to pdf.

Answers that are not supported by reasoning/work will not receive full credit. **Homework is due by 11:59 pm, via Gradescope, on the date above.** Late submissions will **not** be accepted, but you may receive extra credit for early submission (see syllabus for details).

You will also be graded on organization/neatness of the submitted files.

DS 4400 Math Review (42 points)

(1) Assume that x is a scalar variable, find the derivatives with respect to x **by hand** for the following functions.

- (a) $f(x) = \frac{1}{1-x}$
- (b) $f(x, y) = \log_2(2x^3) - 2xy$
- (c) $f(x) = \langle e^x + x \rangle_+$ **Notation Hint:** this is the same as $\text{ReLU}(e^x + x)$

(2) Given the vectors and matrix below, complete the following operations **by hand and in python** (using the provided **HW0_python_sols.ipynb** file).

$$x = \begin{bmatrix} 1 \\ -2 \\ 3 \end{bmatrix}, y = \begin{bmatrix} -4 \\ 1 \end{bmatrix}, W = \begin{bmatrix} 0 & 1 \\ 2 & -1 \\ 1 & 3 \end{bmatrix}$$

- (a) $W^T x - y$
- (b) $(yy^T) \odot (W^T W)$
- (c) $\|x\|_2 - \|y\|_1$

THE HOMEWORK CONTINUES ON THE NEXT PAGE

Python vs. R (58 points)

(3) On Canvas, there is the **HW0_python_sols.ipynb** file which implements a basic gradient descent algorithm to find the minimum of the function $f(x) = 2x^4 - 3x^3 + 1$.

- (a) Comment the python file extensively to demonstrate that you understand what each part of the program is doing. **Make sure you submit the updated/commented file with the rest of your assignment.**
- (b) Open up RStudio, make sure the **rmarkdown** package is installed, and then create a new .rmd file. Create the vectors and matrix from problem (2) above and perform the operations from problem (2) in R.
- (c) Use R to implement the same gradient descent algorithm as in part (a) of this problem. Make sure to comment your code extensively and display a plot verifying convergence of your algorithm. **Hint:** you should not need to import any libraries; the base version of R has all the functions you need.

Extra Credit Reminders

There are three avenues for Extra Credit on this assignment:

- (a) Submit more than 24 hours early (before Sunday, Jan. 11 at 11:59 pm) for 5% extra credit on the worked parts of the assignment.
- (b) Complete the Getting to Know You Google Form and submit proof to Gradescope by Monday, Jan. 12 at 11:59 pm for 1 point extra credit.
- (c) Register/sign up for Piazza (accessible through Canvas) by Monday, Jan. 12 at 11:59 pm for 1 point extra credit.