

# Homework 1

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[Link to the Github repository](#)

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**!** Due: Sun, Jan 29, 2023 @ 11:59pm

Please read the instructions carefully before submitting your assignment.

1. This assignment requires you to:
  - Upload your Quarto markdown files to a `git` repository
  - Upload a `PDF` file on Canvas
2. Don't collapse any code cells before submitting.
3. Remember to make sure all your code output is rendered properly before uploading your submission.

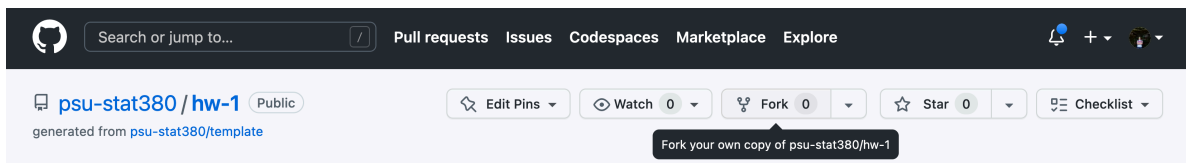
Please add your name to the the author information in the frontmatter before submitting your assignment.

## Question 1

💡 20 points

In this question, we will walk through the process of *forking* a `git` repository and submitting a *pull request*.

1. Navigate to the Github repository [here](#) and fork it by clicking on the icon in the top right



Provide a sensible name for your forked repository when prompted.

2. Clone your Github repository on your local machine

```
$ git clone <<insert your repository url here>>
$ cd hw-1
```

Alternatively, you can use Github codespaces to get started from your repository directly.

3. In order to activate the R environment for the homework, make sure you have `renv` installed beforehand. To activate the `renv` environment for this assignment, open an instance of the R console from within the directory and type

```
renv::activate()
```

Follow the instructions in order to make sure that `renv` is configured correctly.

4. Work on the *remaining part* of this assignment as a `.qmd` file.
  - Create a PDF and HTML file for your output by modifying the YAML frontmatter for the Quarto `.qmd` document
5. When you're done working on your assignment, push the changes to your github repository.


6. Navigate to the original Github repository [here](#) and submit a pull request linking to your repository.

Remember to **include your name** in the pull request information!

If you're stuck at any step along the way, you can refer to the [official Github docs here](#)

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## Question 2

 30 points

Consider the following vector

```
my_vec <- c(
  "+0.07",
  "-0.07",
  "+0.25",
  "-0.84",
  "+0.32",
  "-0.24",
  "-0.97",
  "-0.36",
  "+1.76",
  "-0.36"
)
```

For the following questions, provide your answers in a code cell.

1. What data type does the vector contain?

```
typeof(my_vec)
```

```
[1] "character"
```

2. Create two new vectors called `my_vec_double` and `my_vec_int` which converts `my_vec` to Double & Integer types, respectively,

```
my_vec_double <- as.numeric(my_vec)
typeof(my_vec_double)
```

```
[1] "double"
```

```
my_vec_int <- as.integer(my_vec)
typeof(my_vec_int)
```

```
[1] "integer"
```

3. Create a new vector `my_vec_bool` which comprises of:

- TRUE if an element in `my_vec_double` is  $\leq 0$
- FALSE if an element in `my_vec_double` is  $\geq 0$

How many elements of `my_vec_double` are greater than zero?

```
my_vec_bool <- c()
count = 0

for (i in my_vec_double) {
  if (i > 0) {
    my_vec_bool <- append(my_vec_bool, "TRUE", after = length(my_vec_bool))
    count <- count + 1
  }
  else{
    my_vec_bool <- append(my_vec_bool, "FALSE", after = length(my_vec_bool))
  }
}
my_vec_bool
```

```
[1] "TRUE" "FALSE" "TRUE" "FALSE" "TRUE" "FALSE" "FALSE" "FALSE" "TRUE"
[10] "FALSE"
```

```
print(paste("There are", count, "elements in 'my_vec_double' greater than zero"))
```

```
[1] "There are 4 elements in 'my_vec_double' greater than zero"
```

4. Sort the values of `my_vec_double` in ascending order.

```
sort(my_vec_double)
```

```
[1] -0.97 -0.84 -0.36 -0.36 -0.24 -0.07  0.07  0.25  0.32  1.76
```

### Question 3

💡 50 points

In this question we will get a better understanding of how R handles large data structures in memory.

1. Provide R code to construct the following matrices:

$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix} \quad \text{and} \quad \begin{bmatrix} 1 & 2 & 3 & 4 & 5 & \dots & 100 \\ 1 & 4 & 9 & 16 & 25 & \dots & 10000 \end{bmatrix}$$

#### ⚠ Tip

Recall the discussion in class on how R fills in matrices

```
matrix(  
  c(1,2,3,4,5,6,7,8,9),  
  nrow = 3,  
  byrow = TRUE  
)
```

	[,1]	[,2]	[,3]
[1,]	1	2	3
[2,]	4	5	6
[3,]	7	8	9

```
matrix(  
  c((1:100),(1:100)^2),  
  nrow = 2,  
  byrow = TRUE  
)
```

	[,1]	[,2]	[,3]	[,4]	[,5]	[,6]	[,7]	[,8]	[,9]	[,10]	[,11]	[,12]	[,13]	[,14]
[1,]	1	2	3	4	5	6	7	8	9	10	11	12	13	14
[2,]	1	4	9	16	25	36	49	64	81	100	121	144	169	196
	[,15]	[,16]	[,17]	[,18]	[,19]	[,20]	[,21]	[,22]	[,23]	[,24]	[,25]	[,26]		
[1,]	15	16	17	18	19	20	21	22	23	24	25	26		

```

[2,] 225 256 289 324 361 400 441 484 529 576 625 676
     [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37] [,38]
[1,] 27 28 29 30 31 32 33 34 35 36 37 38
[2,] 729 784 841 900 961 1024 1089 1156 1225 1296 1369 1444
     [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48] [,49] [,50]
[1,] 39 40 41 42 43 44 45 46 47 48 49 50
[2,] 1521 1600 1681 1764 1849 1936 2025 2116 2209 2304 2401 2500
     [,51] [,52] [,53] [,54] [,55] [,56] [,57] [,58] [,59] [,60] [,61] [,62]
[1,] 51 52 53 54 55 56 57 58 59 60 61 62
[2,] 2601 2704 2809 2916 3025 3136 3249 3364 3481 3600 3721 3844
     [,63] [,64] [,65] [,66] [,67] [,68] [,69] [,70] [,71] [,72] [,73] [,74]
[1,] 63 64 65 66 67 68 69 70 71 72 73 74
[2,] 3969 4096 4225 4356 4489 4624 4761 4900 5041 5184 5329 5476
     [,75] [,76] [,77] [,78] [,79] [,80] [,81] [,82] [,83] [,84] [,85] [,86]
[1,] 75 76 77 78 79 80 81 82 83 84 85 86
[2,] 5625 5776 5929 6084 6241 6400 6561 6724 6889 7056 7225 7396
     [,87] [,88] [,89] [,90] [,91] [,92] [,93] [,94] [,95] [,96] [,97] [,98]
[1,] 87 88 89 90 91 92 93 94 95 96 97 98
[2,] 7569 7744 7921 8100 8281 8464 8649 8836 9025 9216 9409 9604
     [,99] [,100]
[1,] 99 100
[2,] 9801 10000

```

In the next part, we will discover how knowledge of the way in which a matrix is stored in memory can inform better code choices. To this end, the following function takes an input  $n$  and creates an  $n \times n$  matrix with random entries.

```

generate_matrix <- function(n){
  return(
    matrix(
      rnorm(n^2),
      nrow=n
    )
  )
}

```

For example:

```
generate_matrix(4)
```

```

      [,1]      [,2]      [,3]      [,4]
[1,] -1.4948687 -0.54995952 -0.475262874 -1.6261801

```

```
[2,] 2.3997342 1.15291523 0.004781135 -1.3075263
[3,] 0.7088222 0.54523373 -0.653832415 -0.9220494
[4,] -0.6436038 0.01736334 -0.579846545 -0.5011851
```

Let  $M$  be a fixed  $50 \times 50$  matrix

```
M <- generate_matrix(50)
mean(M)
```

```
[1] 0.01896509
```

2. Write a function `row_wise_scan` which scans the entries of  $M$  one row after another and outputs the number of elements whose value is  $\geq 0$ . You can use the following **starter code**

```
row_wise_scan <- function(x){
  n <- nrow(x)
  m <- ncol(x)

  # Insert your code here
  count <- 0
  for(row in 1:n){
    for(col in 1:m){
      if(x[row,col] >= 0){
        count <- count + 1
      }
    }
  }

  return(count)
}
```

3. Similarly, write a function `col_wise_scan` which does exactly the same thing but scans the entries of  $M$  one column after another

```
col_wise_scan <- function(x){
  count <- 0
  # Insert your code
  n <- nrow(x)
  m <- ncol(x)
  for(col in 1:m){
    for(row in 1:n){
```

```

        if(x[row,col] >= 0){
          count <- count + 1
        }
      }
    }

    return(count)
  }
}

```

You can check if your code is doing what it's supposed to using the function here<sup>1</sup>

4. Between `col_wise_scan` and `row_wise_scan`, which function do you expect to take shorter to run? Why?

I would think that the 'col\_wise\_scan' would take shorter to run. I think this because matrices in R naturally fill column by column, so I feel as if that might play a role in the 'col\_wise\_scan' being quicker than the 'row\_wise\_scan'.

5. Write a function `time_scan` which takes in a method `f` and a matrix `M` and outputs the amount of time taken to run `f(M)`

```

time_scan <- function(f, M){
  initial_time <- Sys.time()
  f(M)
  final_time <- Sys.time()

  total_time_taken <- final_time - initial_time
  return(total_time_taken)
}

```

Provide your output to

```

list(
  row_wise_time = time_scan(row_wise_scan, M),
  col_wise_time = time_scan(col_wise_scan, M)
)

```

---

<sup>1</sup>If your code is right, the following code should evaluate to be `TRUE`

```

library(tidyverse)
sapply(1:100, function(i) {
  x <- generate_matrix(100)
  row_wise_scan(x) == col_wise_scan(x)
}) %>% sum == 100

```



```
)
```

```
$row_wise_time  
Time difference of 0.006110907 secs
```

```
$col_wise_time  
Time difference of 0.006309032 secs
```

Which took longer to run?

The `col_wise_scan` function took longer to run than the `row_wise_scan` function.

6. Repeat this experiment now when:

- M is a  $100 \times 100$  matrix

```
M <- generate_matrix(100)  
list(  
  row_wise_time = time_scan(row_wise_scan, M),  
  col_wise_time = time_scan(col_wise_scan, M)  
)
```

```
$row_wise_time  
Time difference of 0.0006570816 secs
```

```
$col_wise_time  
Time difference of 0.0006411076 secs
```

- `M` is a  $1000 \times 1000$  matrix

```
M <- generate_matrix(1000)  
list(  
  row_wise_time = time_scan(row_wise_scan, M),  
  col_wise_time = time_scan(col_wise_scan, M)  
)
```

- `M` is a  $5000 \times 5000$  matrix

```
M <- generate_matrix(5000)
list(
  row_wise_time = time_scan(row_wise_scan, M),
  col_wise_time = time_scan(col_wise_scan, M)
)
```

What can you conclude?

After running the time scans for both matrix scanning methods on various size matrices, I conclude that the `row_wise_scan` is faster than the `col_wise_scan`.

## Appendix

Print your R session information using the following command

```
sessionInfo()
```

```
R version 4.2.2 (2022-10-31 ucrt)
Platform: x86_64-w64-mingw32/x64 (64-bit)
Running under: Windows 10 x64 (build 22000)
```

```
Matrix products: default
```

```
locale:
[1] LC_COLLATE=English_United States.utf8
[2] LC_CTYPE=English_United States.utf8
[3] LC_MONETARY=English_United States.utf8
[4] LC_NUMERIC=C
[5] LC_TIME=English_United States.utf8
```

```
attached base packages:
[1] stats      graphics  grDevices datasets  utils      methods    base
```

```
loaded via a namespace (and not attached):
[1] digest_0.6.31    lifecycle_1.0.3 jsonlite_1.8.4  magrittr_2.0.3
[5] evaluate_0.20    rlang_1.0.6      stringi_1.7.12  cli_3.6.0
[9] renv_0.16.0-53   rstudioapi_0.14 vctrs_0.5.1     rmarkdown_2.20
[13] tools_4.2.2      stringr_1.5.0    glue_1.6.2      xfun_0.36
[17] yaml_2.3.6       fastmap_1.1.0    compiler_4.2.2  htmltools_0.5.4
[21] knitr_1.41
```