BIOS545R Introduction to R Programming
2017 Spring Semester Final Exam

03/01/2017 3:00 – 4:50 PM

INSTRUCTIONS:

Answer all three questions. All work and code must be your own. Save all code into a single text file called LASTNAME_FIRSTNAME_FINAL.R. No email, text, chat (electronic or person-to-person) is allowed during the Final. You may not download packages to solve these problems. You may not Google for code. Before leaving the room please email your file to dvandom@emory.edu and wsp@emory.edu. Total is 100 points. Partial credit will be given.

QUESTION #1) (40 points)

In this question you will write functions to compute the variance of an input vector and the covariance and correlation between two input vectors.

1. Do not use the built in **"var"** (variance function), **"sd"**, or **"cov"** (covariance) functions though you can use the **"mean"** function.
2. Try to vectorize your computations. Using loops is allowed but to receive full credit you should use vectorization where possible.

a) Variance (10 points)

In a sample, the **variance** is the average squared deviation from the sample mean, as defined by the following formula:

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

where x is a vector of length "n" and $\bar{x}$ is the mean of the sample vector. Write a function called **sampvar** that implements this formula. **Check that the input vector is numeric and has length >= 2**. Here is an example:

```
set.seed(123)
x <- rnorm(30,10)

# Note that your answer may print to more or less decimal points
# depending on your default settings in R

sampvar(x)
[1] 0.962

# Do error checking to make sure the input vector is numeric and
# has at least 2 elements
```

```
sampvar(letters)
Error in sampvar(letters) : The input vector is not numeric

sampvar(5)
Error in sampvar(5) : The input vector is less than 2 elements
```

b) Covariance (15 points)

The **covariance** of two variables, (*x* and *y*), in a data sample measures how the two are linearly related. **Check that input vectors are both numeric with length >= 2 and have the same length.** A positive covariance would indicate a positive linear relationship between the variables, and a negative covariance would indicate the opposite. The **sample covariance** is defined in terms of the sample means as:

$$Q = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})$$

$\bar{x}$ and $\bar{y}$ represent the mean of x and y, respectively, and are vectors of length "n". Write a function called "**sampcov**" in R that, given vectors x and y, implements the above formula. Thus, it will return the covariance of two vectors x and y. As an example using the following vectors:

```
set.seed(123)
x <- rnorm(1000)

set.seed(456)
y <- rnorm(1000)

sampcov(x,y)
[1] 0.0134

# The input vectors must be of the same length

x <- rnorm(5)
y <- rnorm(7)

sampcov(x,y)
Error in sampcov(x, y) : The length of both vectors must be the
same

# Both vectors must be numeric

sampcov(x,letters)
Error in sampcov(x, letters) : One or both input vectors is not
numeric
```

c) Pearson's Correlation Coefficient (15 points)

We can compute the **Pearson's correlation coefficient** by using the formula below where x and y are vectors of length "n". s_x and s_x are the standard deviations of x and y respectively. Note that the standard deviation is the square root of the sample variance.

$$r = \frac{cov(x,y)}{s_x * s_y}$$

where $s_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$ and $s_y = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n-1}}$

Write a function called "**mypearson**" that implements the formula for ***r***. Take advantage of the functions you wrote in sections a and b to simplify your work. As an example:

```
set.seed(123)
x <- rnorm(1000)

set.seed(456)
y <- rnorm(1000)

mypearson(x,y)
[1] 0.0137

# Do some error checking

mypearson(x,letters)
Error in mypearson(x, letters) : One or both input vectors is not
numeric

x <- rnorm(5)
y <- rnorm(8)

mypearson(x,y)
Error in mypearson(x, y) : The length of both vectors must be the
same
```

QUESTION #2 (20 points)

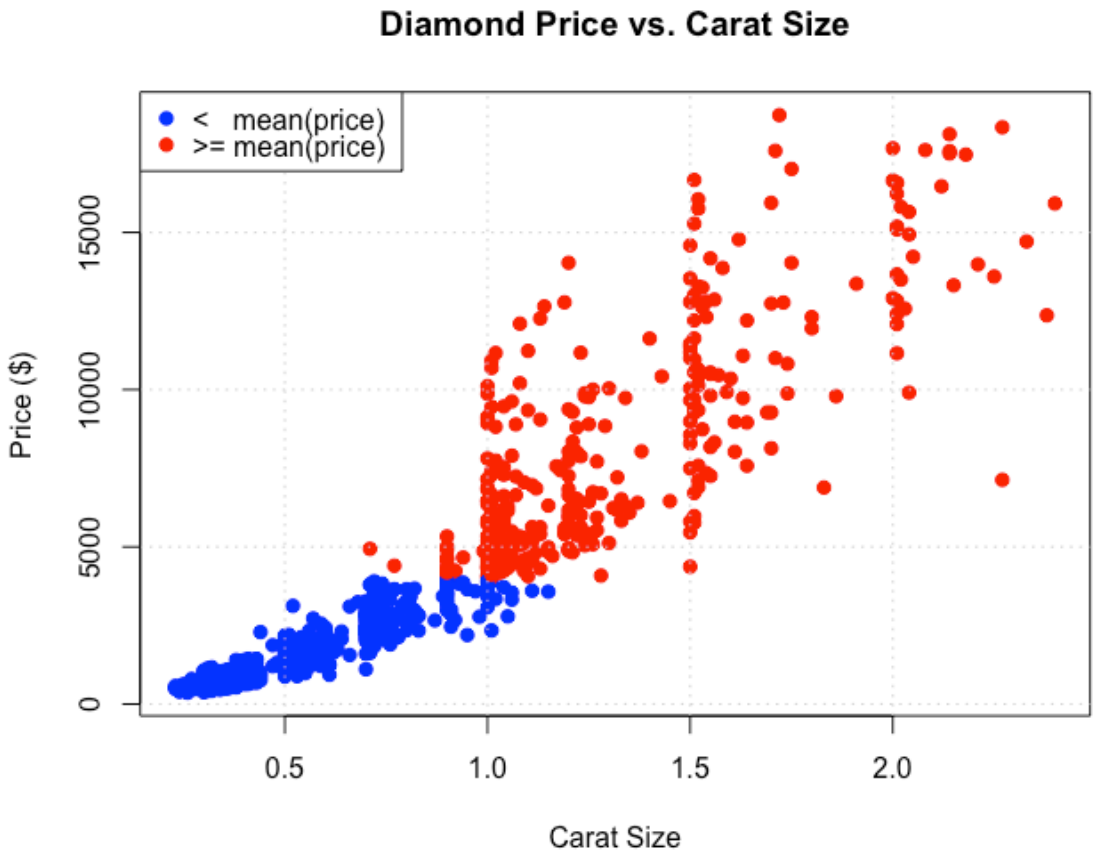
Read the following .csv file in to R.

```
url <- "https://steviep42.bitbucket.org/bios545r_2017/DATA.DIR/my.diamonds.csv"
myd <- read.csv(url)
```

Create a function that presents a plot of price (y axis) vs. carat size (x axis) such that the points lying below the average price have the color blue and the points lying above the average price are in red. Use base graphics to create this function.

```
myplotter(mydf=myd, pch=18)
```

To get full credit the figure generated from the function must have very similar plot character, colors, labels and titles as shown in the example.



QUESTION #3) (40 points)

Write a function called **window** that, given a numeric vector **xvec** and a numeric value **interval,** will compute a moving average for a specified interval of elements **(**e.g. 5**)** starting with the first element and so on. (See the example below for two specific demonstrations). You may **no**t use the **cumsum** or **filter** functions. You can do this easily with a for-loop structure. The function should return a vector containing the means for each "window".

Check that the value for interval is greater than or equal to 1 and less than or equal to the length of xvec.

```
window <- function(xvec, interval=5) {

# xvec:     a numeric vector
# interval: a numeric value representing the size of the interval
#           over which to take the mean loop

   # Get the length of xvec
   # Use a for loop to get the average of each "interval"
   # (e.g. 5) number of elements starting with the first element
```

```
    return(retvec)
}
```

Here are two specific examples: **nums** is a seven-element vector and the value of **interval** is 5. Get the average of every 5 elements starting with the first element. So begin with elements 1-5, then elements 2-6, then elements 3-7. We stop after that because there are only 4 remaining elements, which is less than the **interval** value of 5.

```
set.seed(123)
(nums <- round(runif(7,1,30),0))
[1] 9 24 13 27 28 2 16

window(nums,5)
[1] 20.2 18.8 17.2

9 24 13 27 28 2 16    # mean of nums[1:5] is 20.2
9 24 13 27 28 2 16    # mean of nums[2:6] is 18.8
9 24 13 27 28 2 16    # mean of nums[3:7] is 17.2

# Example 2 – Use a window size of 6

set.seed(123)
(nums <- round(runif(7,1,30),0))
[1] 9 24 13 27 28 2 16

myw(nums,6)
[1] 17.16667 18.33333

9 24 13 27 28 2 16    # mean of nums[1:5] is 17.16667
9 24 13 27 28 2 16    # mean of nums[2:6] is 18.33333
```