Homework 1: ADMI 6807

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Do the following problems using the R programming language. Hint: If unsure about how to use a command use the help function.

1 Basic vector and matrix operations

1. Define three vectors of length 4. The vectors should be of logicals, characters, and numeric repectively. Add and multiply them pairwise and Describe what happens. Look for the function that can be used to concatenate characters. Hint: you can use the $c()$ function to create the vectors.

2. Define three numeric vectors and two scalars (vector of length one). The vectors must be of length equal to the number of characters in your name. At least one of the vectors must be defined using the seq() function and another must be defined using the rnorm() or the runif() function. Let x, y, and v, be the vectors and a, b the scalars. Answer the following questions:

   (a) Describe what do the built-in functions seq(), runif(), rnorm(), and exp() do.
   (b) Display the results and describe what happens when you issue the following commands: $x[2]$, $x[1:3]$, $x[c(1,3)]$, $x[\text{length}(x)+1]$.
   (c) Let v be a vector defined using the seq() function and let c be the median of the elements in the vector. Display the results of the following operations: $v[v < c]$, $v[v < a]$. describe what happened.
   (d) Display the result from the following operations (recall your linear algebra): ax, $ax+y$, $x+(-1)y$, and $(x+y)b$.
   (e) Display and describe what happens when you issue $x*y$. Is this a basic operation in linear algebra.
   (f) Define another vector of $\text{length}(x)+1$ and add it to x. Display result and describe what happens.

3. Define three numeric 2×2 matrices A, B, I where I is the identity matrix. Also, define a vector b of length two and a scalar a. Do the following operations in R:

   (a) The transpose of B, that is, B^T. Hint: the transpose function in R is t().
   (b) $A + bB$.
   (c) $AB - bI$. Hint: the operation for matric multiplication in R is $\% * \%$.
   (d) Define a 2×3 and 3×3 matrix using the function runif() function. Let F and G be such matrices respectively. Display the result and describe what happens when you compute AF and AG.

(e) Describe the function solve() in R. Use it to solve

$$Ax = b. \tag{1}$$

(f) Consider the system of linear equations:

$$3x + 4y \quad = \quad 12 \tag{2}$$
$$x + 2y \quad = \quad 8 \tag{3}$$

Write the system in matrix form and use the function solve() to solve it.

(g) Find the eigenvalues of B using the eigen() function. Recall, the eigenvalues of a square matrix B are defined as the scalars λ that satisfy the following equation: $Bx = \lambda x$ where $x \neq 0$ (here 0 refers to the zero vector).

2   R scripts

R scripts are text files (not word processing documents) with the extension .r that contain a sequence of R commands. They can be run from the R command prompt with the command source('filename.r'). Once the command is issued the script is executed line by line from top to bottom. Recall that in R you can comment lines by inserting the pound character (#) at the beggining of a line.

1. Write a script to do the second problem of last section.

2. Write an algorithm in the form of pseudocode to compute the total price of an item with price p and a sales tax of $r\%$. Implement such algorithm as an R script. Inside your script use print function to display the result. Display results for an item of any price of your choosing and any tax rate of your choosing.

3   Basic plotting in R

The plotting functions in R have several options in order to customize the look of the plots to our liking. In this section we will use the functions hist(), boxplot, and plot() to make histograms, boxplots, and scatter plots respectively. You should study the help entry of these functions to see all the possible options. The most commonly used options are:

- 'main' for overall title. Note that in this case the option must be set to a character or character string.

- 'sub' for a subtitle.

- 'xlab' and 'ylab' for x-axis and y-axis label respectively.

- 'xlim' and 'ylim' for x-axis and y-axis limits respectively. Notice that in this case the option must be set to a numeric vector of length two.

- 'frame.plot' a logical value that tells the plotting function whether to put a frame around the graph.

Write an R script that does the following.

1. Define a variable a numeric vector of length 1000 using the rnorm function with mean option set to the day of your birthdate and standard deviation set to one. Make a histogram and a boxplot of such variable.

2. Use the function plot to make the graphs of the following functions:

$$f(x) = Ce^{\alpha x} \tag{4}$$

where $C = 1$ $\alpha = 0.5$ and $x \in [0, 10]$.

$$g(t) = A\sin(2\omega t) \tag{5}$$

where $A = 1$ $\omega = 4$ and $t \in [0, 2\pi]$. Hint: define t and x as vectors of some length $n > 0$ and use the built-in R functions that return the sine and exponential functions evaluated in such vectors.

Additional remarks:

- Creating a new graph by issuing a high level plotting command (plot, hist, boxplot, etc.) will typically overwrite a previous graph. To avoid this, open a new graph window before creating a new graph. To open a new graph window use one of the functions below.

Function	Platform
windows()	Windows
X11()	Unix/Linux
quartz()	Mac

You should issue the command before creating a new plot.