R Tutorial

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Installation

- Installing R: `https://www.r-project.org/`
- Recommended to also install R Studio: `https://www.rstudio.com/`

Vectors

Basic element is the column vector

```
# create basic vector
x = c(1,2,3,4,5)
x[1]

## [1] 1
```

The first element of x is 1 given by x[1].

Matrices

Use matrix command to create matrices. Also, matrix operations are similar to vector operations.

```
# create basic matrix
mat=matrix(data=c(9,2,3,4,5,6),ncol=3,nrow=2)
# Show the matrix
mat
```

```
##      [,1] [,2] [,3]
## [1,]    9    3    5
## [2,]    2    4    6
```

```
# Second row of matrix
mat[2,]
```

```
## [1] 2 4 6
```

Matrices (Contd.)

```
# create basic matrix
mat=matrix(data=c(9,2,3,4,5,6),ncol=3,nrow=2)
# Third coloumn of matrix
mat[,3]

## [1] 5 6

# Selecting multiple coloumn
mat[,1:2]

##      [,1] [,2]
## [1,]    9    3
## [2,]    2    4
```

Vector/Matrix Operations

Vector addition and subtraction

```
# create vector
x = c(0,1,2); y = c(1,2,3)
# Vector addition
x + y

## [1] 1 3 5

# Vector subtraction: x - y
```

Dimension

```
# create matrix
mat = matrix(1:12,nrow = 3, ncol = 4)
# Row Dimension
dim(mat)[1]

## [1] 3

# Column dimension: dim(mat)[2]
```

Vector/Matrix Operations (Contd.)

which() function one wishes to find the indices of elements that have a certain characteristic.

```
# create vector
y = c(1,2,3,4,5)
# Show index of even numbers
which(y %% 2 == 0)

## [1] 2 4

# which allows complicated logical expressions
# Select elements from y which are less than 5
# but greater than or equal to 3
which((y >= 3) & (y < 5))

## [1] 3 4
```

Vector/Matrix Operations Contd.

Combined selections for matrices

```
# create matrix
mat <- matrix(1:12, 3, 4, byrow=TRUE)
# Select all columns starting with a number less than 3
mycols = mat[1,] < 3
mycols

## [1]  TRUE  TRUE FALSE FALSE

# Show selected coloumns
mat[ , mycols]

##      [,1] [,2]
## [1,]    1    2
## [2,]    5    6
## [3,]    9   10
```

Vector/Matrix Operations Contd.

Transpose of Matrix

```
# create matrix
mat <- matrix(1:12, 3, 4, byrow=TRUE)
# Transpose using t operator
t(mat)

##      [,1] [,2] [,3]
## [1,]    1    5    9
## [2,]    2    6   10
## [3,]    3    7   11
## [4,]    4    8   12
```

Vector/Matrix Operations Contd.

Binding vectors to create a matrix

- Binding column wise

```
# Create matrix
mat <-cbind(c(1,2), c(3,4))
mat
```

```
##      [,1] [,2]
## [1,]    1    3
## [2,]    2    4
```

- Binding row wise

```
# Create matrix
mat <-rbind(c(1,2), c(3,4))
mat
```

```
##      [,1] [,2]
## [1,]    1    2
## [2,]    3    4
```

Vector/Matrix Operations Contd.

Matrix Multiplication

```
# Create 2 matrices
mat1 <-cbind(c(1,0), c(0,1)) # Identity Matrix
mat2 <- matrix(1:4, 2, 2, byrow=TRUE)
# Element wise multiplication
mat1 * mat2
```

```
##      [,1] [,2]
## [1,]    1    0
## [2,]    0    4
```

```
# Matrix Multiplication
mat1 %*% mat2
```

```
##      [,1] [,2]
## [1,]    1    2
## [2,]    3    4
```

The If-Else control

Syntax: if (test-expression) { if-commands } else { else-commands }
Could be used without the else part.

```
x = -5
if(x > 0){
   print("Non-negative number")
} else {
   print("Negative number")
}

## [1] "Negative number"
```

The For Loop

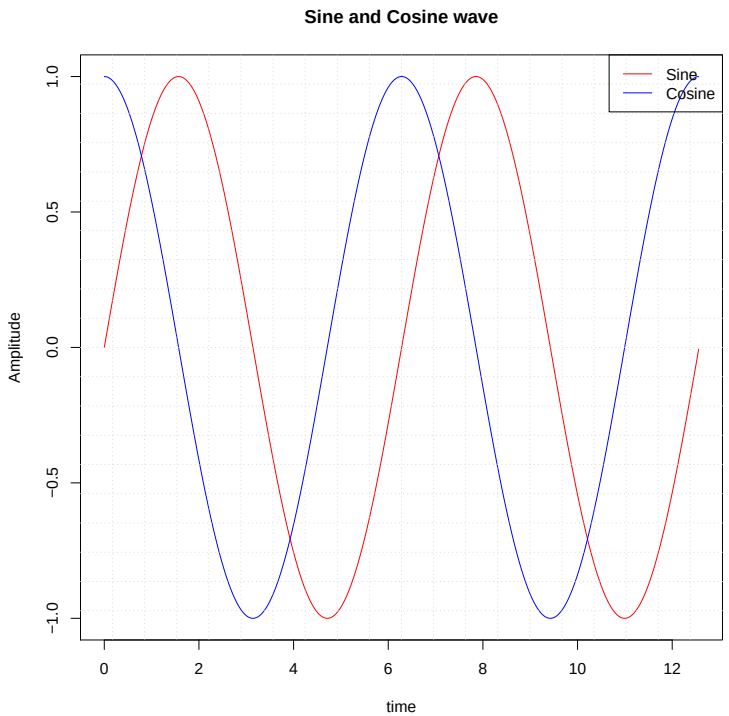
Use the for loop if you want to do the same task a specific number of times. Syntax: for (counter in vector) {commands}

```
for(i in 1:5)
{
  print(i^2)
}
```

```
## [1] 1
## [1] 4
## [1] 9
## [1] 16
## [1] 25
```

Plots

Use plot command for simple plots[1] [2].



[1] For advanced plotting use ggplot2 package

[2] Make sure your figures look like this while submitting your assignments.

Plots contd.

```
# Create a sequence from 0 to 4pi using 0.01 increment
t = seq(0, 4*pi, 0.01)
s=sin(t)
c=cos(t)
# Create a line plot using plot command
plot(t,s,type='l',col='red',xlab="time",ylab="Amplitude")
# Use lines instead of plot to overlay
lines(t,c,type='l',col='blue')
# Switch on grid
grid(nx = 20, ny = 20)
# Use title command for title and axis labels
title(main="Sine and Cosine wave")
# Use legend for distingushing multiple plots
legend("topright", legend=c("Sine","Cosine"), col=c("red","blue"),lwd=1)
```

Printing plots to pdf

Print plots to pdf[3].

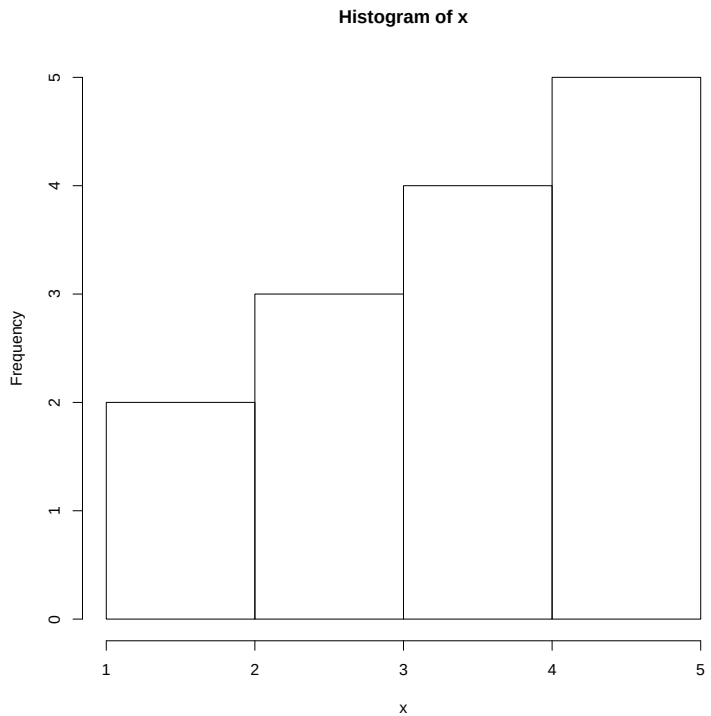
```
pdf("HW1_plot.pdf")
# Plot commands here
dev.off()
```

[3] Use pdf of the plots you generate in your assignment while submitting.

Histogram

A histogram[4] is a visual representation of the distribution of a dataset

```
x = c(1,2,3,3,3,4,4,4,4,5,5,5,5,5)
hist(x)
```



[4] Useful in the second part of the course

Writing your own functions

- Functions can be written both inline or in separate files.
- Use the source command to read functions written in a separate file.

```
fun1 = function(arg1, arg2 )
{
w = arg1 ^ 2
return(arg2 + w)
}
fun1(arg1 = 3, arg2 = 5)

## [1] 14
```

Simulating a coin toss

Using *rbinom*[5]
Fair coin: bias=0.5

```
# Fair coin
rbinom(1,1,0.5)
```

Bias toss: bias=0.1

```
# Biased coin: Probability of getting a heads = 0.1
rbinom(1,1,0.1)
```

[5] We will do this section formally after Lecture 3. In Part 2 of the course, we will simulate the coin toss without any built in commands.

Simulating Binary Communication System

```
#pi0: Probability of 1 #p: P(Y=0|X=0) #q: P(Y=1|X=1)
commsys = function(pi0, p, q)
{ #Simulate X: Input
  X = rbinom(1,1,pi0)
  if (X==0){
    Y = rbinom(1,1,1-p)
  } else{
    # X = 1
    Y = rbinom(1,1,q) }
  commsys=c(X,Y)
  return(commsys) }
pi0 = 2/3; p = 0.9; q = 0.8
N = 100000
data = matrix(NA,N,2)
for (n in 1:N){data[n,] = commsys(pi0,p,q)}
# Probability of error
sum(data[,1]!=data[,2])/N #close to 1/6

## [1] 0.16788
```

Installing packages

- R has a large number of packages[6].
- Use install.packages command to install from CRAN.
- You can also install from source.

```
# Installing ggplot2
install.packages('ggplot2')
```

[6] This is part of the reason R is so widely popular

Getting Help

- Help about a function use the help() command.
- Use the example() command to get examples of a function.
- Additional packages from CRAN.

Submitting assignments

- Submit your code online in Connect before the deadline.
- Optional: Submit a print out of your code.
- Mandatory: Submit a print out of your simulation results.

While submitting code, please ensure to do the following

- Use .R or .m extension.
- Name the file as HWx_QnNo.m (HWx_QnNo.R). For example, the code for Question 8 of Homework 1 should be named as HW1_8.m (HW1_8.R)
- Please zip all the files and rename it to StudentNo_HW1.zip. (Do not use anything else other than zip. Your assignment won't be graded.)
- Write comments! You can get most of the credit if your logic is correct.


Thank You