R Objects, workflows, and functions

Create a vector

```
set.seed(42) ##ensures same random numbers selected
my_unif <- runif(30)
is.vector(my_unif) ## = True
```

```
[1] TRUE
```

```
my_unif[1:10]
```

```
 [1] 0.9148060 0.9370754 0.2861395 0.8304476 0.6417455 0.5190959 0.7365883
 [8] 0.1346666 0.6569923 0.7050648
```

```
my_unif[c(1:3, 15:17)]
```

```
[1] 0.9148060 0.9370754 0.2861395 0.4622928 0.9400145 0.9782264
```

Sort the vector

```
sort(my_unif)
```

```
 [1] 0.08243756 0.11748736 0.13466660 0.13871017 0.25542882 0.28613953
 [7] 0.39020347 0.44696963 0.45774178 0.46229282 0.47499708 0.51421178
[13] 0.51909595 0.56033275 0.64174552 0.65699229 0.70506478 0.71911225
[19] 0.73658831 0.83044763 0.83600426 0.90403139 0.90573813 0.91480604
[25] 0.93467225 0.93707541 0.94001452 0.94666823 0.97822643 0.98889173
```

Create a vector with strings in it

```r
char_vec <- c('daf', 'Adf', '12h', 'h3')
sort(char_vec) #numbers, then uppercase, then lowercase
```

```
[1] "12h" "Adf" "daf" "h3"
```

Create a matrix

```r
#basic call, default fills in matrix by column (left then right)
my_mat1 <- matrix(c(1, 3, 4, -1, 5, 6),
                  nrow = 3,
                  ncol = 2)
my_mat1
```

```
     [,1] [,2]
[1,]    1   -1
[2,]    3    5
[3,]    4    6
```

```r
#changes default to fill in by row (left to right)
my_mat2 <- matrix(c(1, 3, 4, -1, 5, 6),
                  nrow = 3,
                  ncol = 2,
                  byrow = TRUE)
my_mat2
```

```
     [,1] [,2]
[1,]    1    3
[2,]    4   -1
[3,]    5    6
```

```r
#name the columns
my_mat3 <- matrix(c(runif(10),
                    rnorm(10),
                    rgamma(10, shape = 1, scale = 1)),
                  ncol = 3,
                  dimnames = list(1:10, c("Uniform", "Normal", "Gamma")))
my_mat3
```

```
       Uniform     Normal     Gamma
1  0.737595618 -0.3066386 0.8739106
2  0.811055141 -1.7813084 1.1225942
3  0.388108283 -0.1719174 1.4997885
4  0.685169729  1.2146747 0.1621219
5  0.003948339  1.8951935 0.1259051
6  0.832916080 -0.4304691 0.0991477
7  0.007334147 -0.2572694 0.9951484
8  0.207658973 -1.7631631 0.3007788
9  0.906601408  0.4600974 0.6562719
10 0.611778643 -0.6399949 0.2772845
```

Create an Array

```r
my_array <- array(1:24, dim = c(4, 2, 3))
my_array
```

```
, , 1

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

, , 2

     [,1] [,2]
[1,]    9   13
[2,]   10   14
[3,]   11   15
[4,]   12   16

, , 3

     [,1] [,2]
[1,]   17   21
[2,]   18   22
[3,]   19   23
[4,]   20   24
```

```r
#access your array
my_array[1,1,1]
```

```
[1] 1
```

Create a Data Frame

data.frame(..., row.names = NULL, check.rows = FALSE, check.names = TRUE, fix.empty.names = TRUE, stringsAsFactors = FALSE)

```r
x <- c("a", "b", "c", "d", "e", "f")
y <- c(1, 3, 4, -1, 5, 6)
z <- 10:15
my_df <- data.frame(char = x, data1 = y, data2 =  z)
my_df
```

```
  char data1 data2
1    a     1    10
2    b     3    11
3    c     4    12
4    d    -1    13
5    e     5    14
6    f     6    15
```

```r
data.frame(number = 1:5, letter = c("a", "b", "c", "d", "e"))
```

```
  number letter
1      1      a
2      2      b
3      3      c
4      4      d
5      5      e
```

```r
head(iris)
```

```
  Sepal.Length Sepal.Width Petal.Length Petal.Width Species
1          5.1         3.5          1.4         0.2  setosa
2          4.9         3.0          1.4         0.2  setosa
3          4.7         3.2          1.3         0.2  setosa
```

```
4          4.6         3.1          1.5         0.2  setosa
5          5.0         3.6          1.4         0.2  setosa
6          5.4         3.9          1.7         0.4  setosa
```

```r
iris[1:4, 2:4] #only 3 selected columns and rows 1-4
```

```
  Sepal.Width Petal.Length Petal.Width
1         3.5          1.4         0.2
2         3.0          1.4         0.2
3         3.2          1.3         0.2
4         3.1          1.5         0.2
```

```r
df1 <- iris[1, ]
str(df1)
```

```
'data.frame':   1 obs. of  5 variables:
 $ Sepal.Length: num 5.1
 $ Sepal.Width : num 3.5
 $ Petal.Length: num 1.4
 $ Petal.Width : num 0.2
 $ Species     : Factor w/ 3 levels "setosa","versicolor",..: 1
```

```r
df2 <- iris[1, , drop = FALSE]
str(df2)
```

```
'data.frame':   1 obs. of  5 variables:
 $ Sepal.Length: num 5.1
 $ Sepal.Width : num 3.5
 $ Petal.Length: num 1.4
 $ Petal.Width : num 0.2
 $ Species     : Factor w/ 3 levels "setosa","versicolor",..: 1
```

```r
iris$Sepal.Length #access single column
```

```
  [1] 5.1 4.9 4.7 4.6 5.0 5.4 4.6 5.0 4.4 4.9 5.4 4.8 4.8 4.3 5.8 5.7 5.4 5.1
 [19] 5.7 5.1 5.4 5.1 4.6 5.1 4.8 5.0 5.0 5.2 5.2 4.7 4.8 5.4 5.2 5.5 4.9 5.0
 [37] 5.5 4.9 4.4 5.1 5.0 4.5 4.4 5.0 5.1 4.8 5.1 4.6 5.3 5.0 7.0 6.4 6.9 5.5
 [55] 6.5 5.7 6.3 4.9 6.6 5.2 5.0 5.9 6.0 6.1 5.6 6.7 5.6 5.8 6.2 5.6 5.9 6.1
 [73] 6.3 6.1 6.4 6.6 6.8 6.7 6.0 5.7 5.5 5.5 5.8 6.0 5.4 6.0 6.7 6.3 5.6 5.5
```

```
 [91] 5.5 6.1 5.8 5.0 5.6 5.7 5.7 6.2 5.1 5.7 6.3 5.8 7.1 6.3 6.5 7.6 4.9 7.3
[109] 6.7 7.2 6.5 6.4 6.8 5.7 5.8 6.4 6.5 7.7 7.7 6.0 6.9 5.6 7.7 6.3 6.7 7.2
[127] 6.2 6.1 6.4 7.2 7.4 7.9 6.4 6.3 6.1 7.7 6.3 6.4 6.0 6.9 6.7 6.9 5.8 6.8
[145] 6.7 6.7 6.3 6.5 6.2 5.9
```

Data frame video

```
data(trees)
trees
```

```
   Girth Height Volume
1    8.3     70   10.3
2    8.6     65   10.3
3    8.8     63   10.2
4   10.5     72   16.4
5   10.7     81   18.8
6   10.8     83   19.7
7   11.0     66   15.6
8   11.0     75   18.2
9   11.1     80   22.6
10  11.2     75   19.9
11  11.3     79   24.2
12  11.4     76   21.0
13  11.4     76   21.4
14  11.7     69   21.3
15  12.0     75   19.1
16  12.9     74   22.2
17  12.9     85   33.8
18  13.3     86   27.4
19  13.7     71   25.7
20  13.8     64   24.9
21  14.0     78   34.5
22  14.2     80   31.7
23  14.5     74   36.3
24  16.0     72   38.3
25  16.3     77   42.6
26  17.3     81   55.4
27  17.5     82   55.7
28  17.9     80   58.3
29  18.0     80   51.5
30  18.0     80   51.0
31  20.6     87   77.0
```

```
str(trees)
```

```
'data.frame':   31 obs. of  3 variables:
 $ Girth : num  8.3 8.6 8.8 10.5 10.7 10.8 11 11 11.1 11.2 ...
 $ Height: num  70 65 63 72 81 83 66 75 80 75 ...
 $ Volume: num  10.3 10.3 10.2 16.4 18.8 19.7 15.6 18.2 22.6 19.9 ...
```

subset a column

```
trees$Height
```

```
 [1] 70 65 63 72 81 83 66 75 80 75 79 76 76 69 75 74 85 86 71 64 78 80 74 72 77
[26] 81 82 80 80 80 87
```

Get attributes from the data frame

```
attributes(trees)
```

```
$names
[1] "Girth"  "Height" "Volume"

$class
[1] "data.frame"

$row.names
 [1]  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
[26] 26 27 28 29 30 31
```

```
names(trees) #should be same output as colnames
```

```
[1] "Girth"  "Height" "Volume"
```

```
colnames(trees)
```

```
[1] "Girth"  "Height" "Volume"
```

```
colnames(trees)[2:3]
```

```
[1] "Height" "Volume"
```

##Lists

Investigating data frame from before

```
is.list(trees)
```

```
[1] TRUE
```

```
is.data.frame(trees)
```

```
[1] TRUE
```

Since this is a list, we can subset it as a list

```
trees[1] #list
```

```
   Girth
1    8.3
2    8.6
3    8.8
4   10.5
5   10.7
6   10.8
7   11.0
8   11.0
9   11.1
10  11.2
11  11.3
12  11.4
13  11.4
14  11.7
15  12.0
16  12.9
17  12.9
18  13.3
19  13.7
```

```
20  13.8
21  14.0
22  14.2
23  14.5
24  16.0
25  16.3
26  17.3
27  17.5
28  17.9
29  18.0
30  18.0
31  20.6
```

```
trees[[1]] #turns in a vector
```

```
 [1]  8.3  8.6  8.8 10.5 10.7 10.8 11.0 11.0 11.1 11.2 11.3 11.4 11.4 11.7 12.0
[16] 12.9 12.9 13.3 13.7 13.8 14.0 14.2 14.5 16.0 16.3 17.3 17.5 17.9 18.0 18.0
[31] 20.6
```

Look at linear model fit

```
fit <- lm(Volume ~ Height + Girth, data = trees)
```

Look at structure but restrict info:

```
str(fit, max.level = 1) #first level of structure
```

```
List of 12
 $ coefficients : Named num [1:3] -57.988 0.339 4.708
  ..- attr(*, "names")= chr [1:3] "(Intercept)" "Height" "Girth"
 $ residuals    : Named num [1:31] 5.462 5.746 5.383 0.526 -1.069 ...
  ..- attr(*, "names")= chr [1:31] "1" "2" "3" "4" ...
 $ effects      : Named num [1:31] -167.985 53.863 69.159 -0.884 -2.007 ...
  ..- attr(*, "names")= chr [1:31] "(Intercept)" "Height" "Girth" "" ...
 $ rank         : int 3
 $ fitted.values: Named num [1:31] 4.84 4.55 4.82 15.87 19.87 ...
  ..- attr(*, "names")= chr [1:31] "1" "2" "3" "4" ...
 $ assign       : int [1:3] 0 1 2
 $ qr           :List of 5
  ..- attr(*, "class")= chr "qr"
```

```
 $ df.residual  : int 28
 $ xlevels      : Named list()
 $ call         : language lm(formula = Volume ~ Height + Girth, data = trees)
 $ terms        :Classes 'terms', 'formula'  language Volume ~ Height + Girth
  .. ..- attr(*, "variables")= language list(Volume, Height, Girth)
  .. ..- attr(*, "factors")= int [1:3, 1:2] 0 1 0 0 0 1
  .. .. ..- attr(*, "dimnames")=List of 2
  .. ..- attr(*, "term.labels")= chr [1:2] "Height" "Girth"
  .. ..- attr(*, "order")= int [1:2] 1 1
  .. ..- attr(*, "intercept")= int 1
  .. ..- attr(*, "response")= int 1
  .. ..- attr(*, ".Environment")=<environment: R_GlobalEnv>
  .. ..- attr(*, "predvars")= language list(Volume, Height, Girth)
  .. ..- attr(*, "dataClasses")= Named chr [1:3] "numeric" "numeric" "numeric"
  .. .. ..- attr(*, "names")= chr [1:3] "Volume" "Height" "Girth"
 $ model        :'data.frame':  31 obs. of  3 variables:
  ..- attr(*, "terms")=Classes 'terms', 'formula'  language Volume ~ Height + Girth
  .. .. ..- attr(*, "variables")= language list(Volume, Height, Girth)
  .. .. ..- attr(*, "factors")= int [1:3, 1:2] 0 1 0 0 0 1
  .. .. .. ..- attr(*, "dimnames")=List of 2
  .. .. ..- attr(*, "term.labels")= chr [1:2] "Height" "Girth"
  .. .. ..- attr(*, "order")= int [1:2] 1 1
  .. .. ..- attr(*, "intercept")= int 1
  .. .. ..- attr(*, "response")= int 1
  .. .. ..- attr(*, ".Environment")=<environment: R_GlobalEnv>
  .. .. ..- attr(*, "predvars")= language list(Volume, Height, Girth)
  .. .. ..- attr(*, "dataClasses")= Named chr [1:3] "numeric" "numeric" "numeric"
  .. .. .. ..- attr(*, "names")= chr [1:3] "Volume" "Height" "Girth"
 - attr(*, "class")= chr "lm"
```

some helper functions exist

```
fit$coefficients
```

```
(Intercept)      Height       Girth
-57.9876589   0.3392512   4.7081605
```

```
coef(fit)
```

```
(Intercept)      Height       Girth
-57.9876589   0.3392512   4.7081605
```

```
fit$residuals
```

```
         1          2          3          4          5          6
 5.46234035  5.74614837  5.38301873  0.52588477 -1.06900844 -1.31832696
         7          8          9         10         11         12
-0.59268807 -1.04594918  1.18697860 -0.28758128  2.18459773 -0.46846462
        13         14         15         16         17         18
-0.06846462  0.79384587 -4.85410969 -5.65220290  2.21603352 -6.40648192
        19         20         21         22         23         24
-4.90097760 -3.79703501  0.11181561 -4.30831896  0.91474029 -3.46899800
        25         26         27         28         29         30
-2.27770232  4.45713224  3.47624891  4.87148717 -2.39932888 -2.89932888
        31
 8.48469518
```

```
#no helper for rank: rank(fit)
```

##Logical Statements

```
iris[iris$Species == "setosa" & iris$Petal.Width == 0.2, ]
```

```
   Sepal.Length Sepal.Width Petal.Length Petal.Width Species
1           5.1         3.5          1.4         0.2  setosa
2           4.9         3.0          1.4         0.2  setosa
3           4.7         3.2          1.3         0.2  setosa
4           4.6         3.1          1.5         0.2  setosa
5           5.0         3.6          1.4         0.2  setosa
8           5.0         3.4          1.5         0.2  setosa
9           4.4         2.9          1.4         0.2  setosa
11          5.4         3.7          1.5         0.2  setosa
12          4.8         3.4          1.6         0.2  setosa
15          5.8         4.0          1.2         0.2  setosa
21          5.4         3.4          1.7         0.2  setosa
23          4.6         3.6          1.0         0.2  setosa
25          4.8         3.4          1.9         0.2  setosa
26          5.0         3.0          1.6         0.2  setosa
28          5.2         3.5          1.5         0.2  setosa
29          5.2         3.4          1.4         0.2  setosa
30          4.7         3.2          1.6         0.2  setosa
31          4.8         3.1          1.6         0.2  setosa
```

```
34          5.5         4.2          1.4         0.2  setosa
35          4.9         3.1          1.5         0.2  setosa
36          5.0         3.2          1.2         0.2  setosa
37          5.5         3.5          1.3         0.2  setosa
39          4.4         3.0          1.3         0.2  setosa
40          5.1         3.4          1.5         0.2  setosa
43          4.4         3.2          1.3         0.2  setosa
47          5.1         3.8          1.6         0.2  setosa
48          4.6         3.2          1.4         0.2  setosa
49          5.3         3.7          1.5         0.2  setosa
50          5.0         3.3          1.4         0.2  setosa
```

#If/then/else

Fizz buzz challenge - take in a number - if it is divisible by 3 return fizz - if it divisiabile by 5 return buzz - if it divisible by 15 return fizz buzz

```
number <- 2
if((number %% 15) == 0) {
  print("fizz buzz")
} else if ((number %% 5) == 0) {
  print("buzz")
} else if ((number %% 3) == 0) {
  print("fizz")
} else {
  print("whoops?")
}
```

```
[1] "whoops?"
```

##Loops

Wrap the fizz buzz code into a loop to check for multiple values. And add it into a data frame

```
summary_fb <- data.frame(num =  -1:30)
summary_fb
```

```
   num
1   -1
2    0
3    1
```

```
4    2
5    3
6    4
7    5
8    6
9    7
10   8
11   9
12  10
13  11
14  12
15  13
16  14
17  15
18  16
19  17
20  18
21  19
22  20
23  21
24  22
25  23
26  24
27  25
28  26
29  27
30  28
31  29
32  30
```

```
for(i in -1:30){
             if((i %% 15) == 0) {
              summary_fb[i,2] <- "fizz buzz"
             } else if ((i %% 5) == 0) {
               summary_fb[i,2] <- "buzz"
             } else if ((i %% 3) == 0) {
               summary_fb[i,2] <- "fizz"
             } else {
               summary_fb[i,2] <- "whoops?"
  }
}
summary_fb
```

```
   num        V2
1   -1   whoops?
2    0   whoops?
3    1      fizz
4    2   whoops?
5    3      buzz
6    4      fizz
7    5   whoops?
8    6   whoops?
9    7      fizz
10   8      buzz
11   9   whoops?
12  10      fizz
13  11   whoops?
14  12   whoops?
15  13 fizz buzz
16  14   whoops?
17  15   whoops?
18  16      fizz
19  17   whoops?
20  18      buzz
21  19      fizz
22  20   whoops?
23  21   whoops?
24  22      fizz
25  23      buzz
26  24   whoops?
27  25      fizz
28  26   whoops?
29  27   whoops?
30  28 fizz buzz
31  29   whoops?
32  30   whoops?
```

##vectorized functions

```
ifelse(airquality$Wind >= 15, "HighWind",
          ifelse(airquality$Wind >= 10, "Windy",
                 ifelse(airquality$Wind >= 6, "LightWind",
                        ifelse(airquality$Wind >= 0, "Calm", "Error"))))
```

```
  [1] "LightWind" "LightWind" "Windy"     "Windy"     "Windy"     "Windy"
```

```
  [7] "LightWind" "Windy"     "HighWind"  "LightWind" "LightWind" "LightWind"
 [13] "LightWind" "Windy"     "Windy"     "Windy"     "Windy"     "HighWind"
 [19] "Windy"     "LightWind" "LightWind" "HighWind"  "LightWind" "Windy"
 [25] "HighWind"  "Windy"     "LightWind" "Windy"     "Windy"     "Calm"
 [31] "LightWind" "LightWind" "LightWind" "HighWind"  "LightWind" "LightWind"
 [37] "Windy"     "LightWind" "LightWind" "Windy"     "Windy"     "Windy"
 [43] "LightWind" "LightWind" "Windy"     "Windy"     "Windy"     "HighWind"
 [49] "LightWind" "Windy"     "Windy"     "LightWind" "Calm"      "Calm"
 [55] "LightWind" "LightWind" "LightWind" "Windy"     "Windy"     "Windy"
 [61] "LightWind" "Calm"      "LightWind" "LightWind" "Windy"     "Calm"
 [67] "Windy"     "Calm"      "LightWind" "Calm"      "LightWind" "LightWind"
 [73] "Windy"     "Windy"     "Windy"     "Windy"     "LightWind" "Windy"
 [79] "LightWind" "Calm"      "Windy"     "LightWind" "LightWind" "Windy"
 [85] "LightWind" "LightWind" "LightWind" "Windy"     "LightWind" "LightWind"
 [91] "LightWind" "LightWind" "LightWind" "Windy"     "LightWind" "LightWind"
 [97] "LightWind" "Calm"      "Calm"      "Windy"     "LightWind" "LightWind"
[103] "Windy"     "Windy"     "Windy"     "LightWind" "Windy"     "Windy"
[109] "LightWind" "LightWind" "Windy"     "Windy"     "HighWind"  "Windy"
[115] "Windy"     "LightWind" "Calm"      "LightWind" "Calm"      "LightWind"
[121] "Calm"      "LightWind" "LightWind" "LightWind" "Calm"      "Calm"
[127] "Calm"      "LightWind" "HighWind"  "Windy"     "Windy"     "Windy"
[133] "LightWind" "Windy"     "HighWind"  "LightWind" "Windy"     "Windy"
[139] "LightWind" "Windy"     "Windy"     "Windy"     "LightWind" "Windy"
[145] "LightWind" "Windy"     "Windy"     "HighWind"  "LightWind" "Windy"
[151] "Windy"     "LightWind" "Windy"
```

Writing Functions

generic syntax

nameOfFunction <- function(input1, input2, ...) { #code #return something with return() #or returns last value }

```
standardize <- function(vector){
  return((vector - mean(vector))/ sd(vector))
}
```

Create a dataset and apply the function

```
set.seed(10)
data <- runif(15)
data
```

```
 [1] 0.50747820 0.30676851 0.42690767 0.69310208 0.08513597 0.22543662
 [7] 0.27453052 0.27230507 0.61582931 0.42967153 0.65165567 0.56773775
[13] 0.11350898 0.59592531 0.35804998
```

```
result <- standardize(data)
result
```

```
 [1]  0.51053294 -0.52232963  0.09591275  1.46576309 -1.66286222 -0.94086777
 [7] -0.68822797 -0.69968029  1.06811337  0.11013572  1.25247769  0.82063172
[13] -1.51685322  0.96568634 -0.25843252
```

```
#check for mean 0 and sd = 1
round(mean(result), digits = 0)
```

```
[1] 0
```

```
sd(result)
```

```
[1] 1
```

update function to automatically return mean & SD and default values

```
standardize <- function(vector, center = TRUE, scale = TRUE){
  mean <- round(mean(vector))
  stdev <- sd(vector)
  if (center) {
    vector <- vector - mean
    }
  if (scale) {
    vector <- vector / stdev
    }
  return(list(result = vector, mean = mean, sd = stdev))
  }
```

Apply it

```
result <- standardize(data)
result
```

```
$result
 [1] 2.6115093 1.5786467 2.1968891 3.5667395 0.4381141 1.1601086 1.4127484
 [8] 1.4012961 3.1690897 2.2111121 3.3534540 2.9216081 0.5841231 3.0666627
[15] 1.8425438

$mean
[1] 0

$sd
[1] 0.1943237
```

```
result[[2]] # only mean
```

```
[1] 0
```

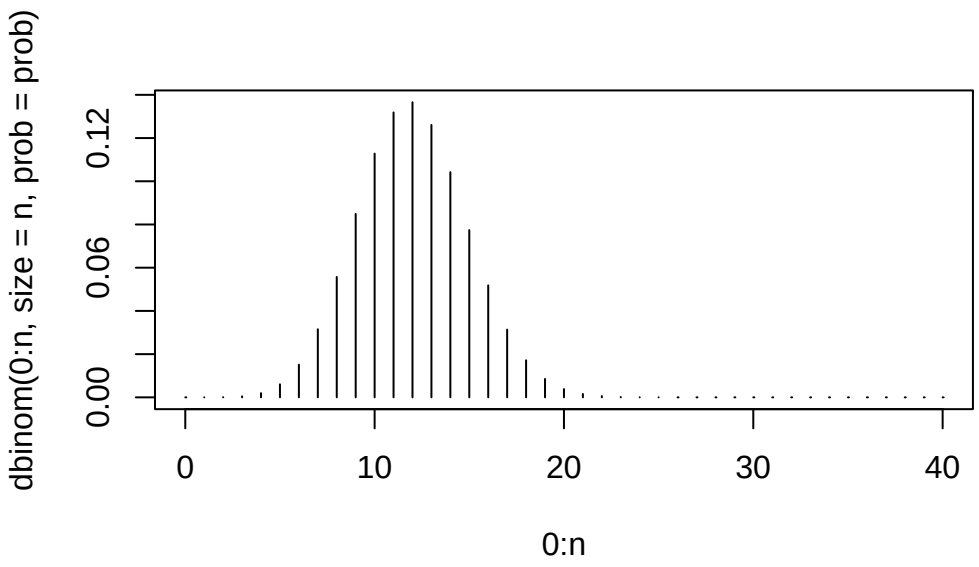
Writing R video

Normal approximation LO the binomial.

```
n <-40
prob <-0.3
#probabilities from a binomial RV
dbinom(0:n, size = n, prob = prob)
```

```
 [1] 6.366806e-07 1.091452e-05 9.121424e-05 4.951630e-04 1.962968e-03
 [6] 6.057157e-03 1.514289e-02 3.152194e-02 5.572629e-02 8.491625e-02
[11] 1.128173e-01 1.318644e-01 1.365738e-01 1.260681e-01 1.041992e-01
[16] 7.740510e-02 5.183378e-02 3.136161e-02 1.717422e-02 8.522543e-03
[21] 3.835144e-03 1.565365e-03 5.793884e-04 1.943290e-04 5.899274e-05
[26] 1.618087e-05 4.000763e-06 8.890585e-07 1.769045e-07 3.137223e-08
[31] 4.929921e-09 6.815560e-10 8.215184e-11 8.535256e-12 7.531108e-13
[36] 5.533059e-14 3.293487e-15 1.525940e-16 5.162955e-18 1.134715e-19
[41] 1.215767e-21
```

```
#plot
plot(0:n, dbinom(0:n, size = n, prob = prob),
     type = "h") #type h for histogram
```




```
#plot normal distribution
norm_x <- seq(from = 0, to = n, length = 1000)
dnorm(norm_x, mean = n*prob, sd = sqrt(n*prob*(1-prob)))
```

```
  [1] 2.607632e-05 2.760874e-05 2.922563e-05 3.093131e-05 3.273029e-05
  [6] 3.462729e-05 3.662725e-05 3.873533e-05 4.095691e-05 4.329765e-05
 [11] 4.576343e-05 4.836040e-05 5.109499e-05 5.397391e-05 5.700417e-05
 [16] 6.019305e-05 6.354820e-05 6.707756e-05 7.078943e-05 7.469244e-05
 [21] 7.879560e-05 8.310831e-05 8.764033e-05 9.240185e-05 9.740348e-05
 [26] 1.026562e-04 1.081716e-04 1.139616e-04 1.200386e-04 1.264154e-04
 [31] 1.331057e-04 1.401232e-04 1.474826e-04 1.551989e-04 1.632877e-04
 [36] 1.717653e-04 1.806486e-04 1.899551e-04 1.997028e-04 2.099108e-04
 [41] 2.205984e-04 2.317859e-04 2.434943e-04 2.557453e-04 2.685615e-04
 [46] 2.819661e-04 2.959832e-04 3.106379e-04 3.259560e-04 3.419641e-04
 [51] 3.586899e-04 3.761621e-04 3.944100e-04 4.134642e-04 4.333563e-04
 [56] 4.541186e-04 4.757849e-04 4.983898e-04 5.219690e-04 5.465595e-04
 [61] 5.721992e-04 5.989274e-04 6.267844e-04 6.558119e-04 6.860528e-04
 [66] 7.175513e-04 7.503526e-04 7.845037e-04 8.200526e-04 8.570487e-04
 [71] 8.955430e-04 9.355876e-04 9.772363e-04 1.020544e-03 1.065568e-03
 [76] 1.112366e-03 1.160998e-03 1.211524e-03 1.264008e-03 1.318514e-03
 [81] 1.375108e-03 1.433857e-03 1.494831e-03 1.558101e-03 1.623738e-03
 [86] 1.691818e-03 1.762416e-03 1.835609e-03 1.911477e-03 1.990101e-03
```

```
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 [96] 2.524473e-03 2.624802e-03 2.728598e-03 2.835956e-03 2.946977e-03
[101] 3.061759e-03 3.180404e-03 3.303017e-03 3.429702e-03 3.560567e-03
[106] 3.695719e-03 3.835270e-03 3.979330e-03 4.128014e-03 4.281435e-03
[111] 4.439712e-03 4.602961e-03 4.771302e-03 4.944855e-03 5.123744e-03
[116] 5.308091e-03 5.498021e-03 5.693661e-03 5.895136e-03 6.102577e-03
[121] 6.316111e-03 6.535869e-03 6.761983e-03 6.994584e-03 7.233806e-03
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[131] 8.815681e-03 9.105013e-03 9.402047e-03 9.706918e-03 1.001976e-02
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[146] 1.402567e-02 1.444458e-02 1.487316e-02 1.531154e-02 1.575984e-02
[151] 1.621816e-02 1.668663e-02 1.716535e-02 1.765443e-02 1.815399e-02
[156] 1.866412e-02 1.918492e-02 1.971649e-02 2.025892e-02 2.081231e-02
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```

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[811] 2.220453e-12 2.014198e-12 1.826753e-12 1.656436e-12 1.501711e-12
[816] 1.361180e-12 1.233564e-12 1.117699e-12 1.012524e-12 9.170705e-13
[821] 8.304573e-13 7.518808e-13 6.806092e-13 6.159759e-13 5.573741e-13
[826] 5.042512e-13 4.561043e-13 4.124758e-13 3.729495e-13 3.371464e-13
[831] 3.047223e-13 2.753640e-13 2.487866e-13 2.247315e-13 2.029636e-13
[836] 1.832692e-13 1.654542e-13 1.493425e-13 1.347739e-13 1.216034e-13
[841] 1.096989e-13 9.894101e-14 8.922105e-14 8.044064e-14 7.251048e-14
[846] 6.534963e-14 5.888472e-14 5.304925e-14 4.778295e-14 4.303123e-14
[851] 3.874464e-14 3.487841e-14 3.139199e-14 2.824868e-14 2.541526e-14
[856] 2.286167e-14 2.056073e-14 1.848784e-14 1.662077e-14 1.493940e-14
[861] 1.342555e-14 1.206280e-14 1.083631e-14 9.732668e-15 8.739757e-15
[866] 7.846645e-15 7.043454e-15 6.321273e-15 5.672055e-15 5.088544e-15
[871] 4.564189e-15 4.093087e-15 3.669909e-15 3.289855e-15 2.948597e-15
[876] 2.642233e-15 2.367249e-15 2.120479e-15 1.899070e-15 1.700455e-15
[881] 1.522322e-15 1.362589e-15 1.219383e-15 1.091020e-15 9.759838e-16
[886] 8.729100e-16 7.805728e-16 6.978699e-16 6.238104e-16 5.575039e-16
[891] 4.981502e-16 4.450305e-16 3.974993e-16 3.549769e-16 3.169429e-16
[896] 2.829299e-16 2.525189e-16 2.253337e-16 2.010367e-16 1.793254e-16
[901] 1.599283e-16 1.426021e-16 1.271287e-16 1.133127e-16 1.009789e-16
[906] 8.997037e-17 8.014671e-17 7.138205e-17 6.356373e-17 5.659094e-17
[911] 5.037343e-17 4.483047e-17 3.988982e-17 3.548690e-17 3.156393e-17
[916] 2.806928e-17 2.495678e-17 2.218518e-17 1.971762e-17 1.752117e-17
[921] 1.556642e-17 1.382712e-17 1.227981e-17 1.090357e-17 9.679723e-18
[926] 8.591604e-18 7.624347e-18 6.764694e-18 6.000823e-18 5.322192e-18
[931] 4.719406e-18 4.184093e-18 3.708792e-18 3.286855e-18 2.912366e-18
[936] 2.580051e-18 2.285219e-18 2.023692e-18 1.791753e-18 1.586095e-18
[941] 1.403774e-18 1.242173e-18 1.098966e-18 9.720836e-19 8.596863e-19
[946] 7.601399e-19 6.719921e-19 5.939528e-19 5.248761e-19 4.637445e-19
```

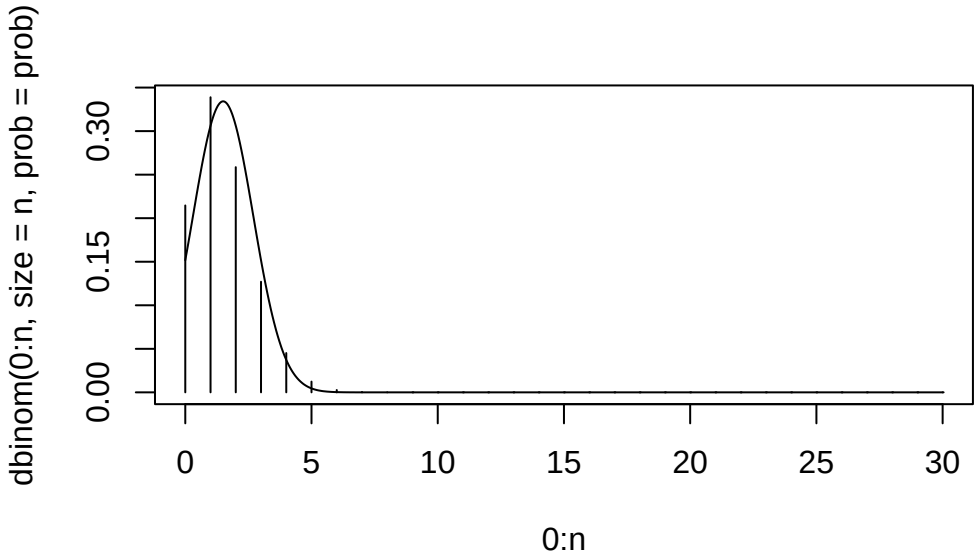
```
 [951] 4.096546e-19 3.618046e-19 3.194827e-19 2.820576e-19 2.489690e-19
 [956] 2.197202e-19 1.938705e-19 1.710293e-19 1.508504e-19 1.330269e-19
 [961] 1.172870e-19 1.033897e-19 9.112165e-20 8.029400e-20 7.073946e-20
 [966] 6.230996e-20 5.487447e-20 4.831704e-20 4.253510e-20 3.743791e-20
 [971] 3.294526e-20 2.898621e-20 2.549805e-20 2.242537e-20 1.971920e-20
 [976] 1.733629e-20 1.523843e-20 1.339187e-20 1.176683e-20 1.033701e-20
 [981] 9.079193e-21 7.972908e-21 7.000087e-21 6.144792e-21 5.392971e-21
 [986] 4.732232e-21 4.151654e-21 3.641609e-21 3.193616e-21 2.800200e-21
 [991] 2.454781e-21 2.151559e-21 1.885433e-21 1.651908e-21 1.447031e-21
 [996] 1.267322e-21 1.109720e-21 9.715309e-22 8.503879e-22 7.442085e-22
```

lets write a function to make this plot for any n and p we give it.

```r
plot_norm_approx <- function(n, prob){
  plot(0:n, dbinom(0:n, size = n, prob = prob),
     type = "h") #type h for histogram
  #plot normal distribution
  norm_x <- seq(from = 0, to = n, length = 1000)
  lines(norm_x,
        dnorm(norm_x,
              mean = n*prob,
              sd = sqrt(n*prob*(1-prob)))
        )
}
```

Test

```r
plot_norm_approx(30, 0.05)
```

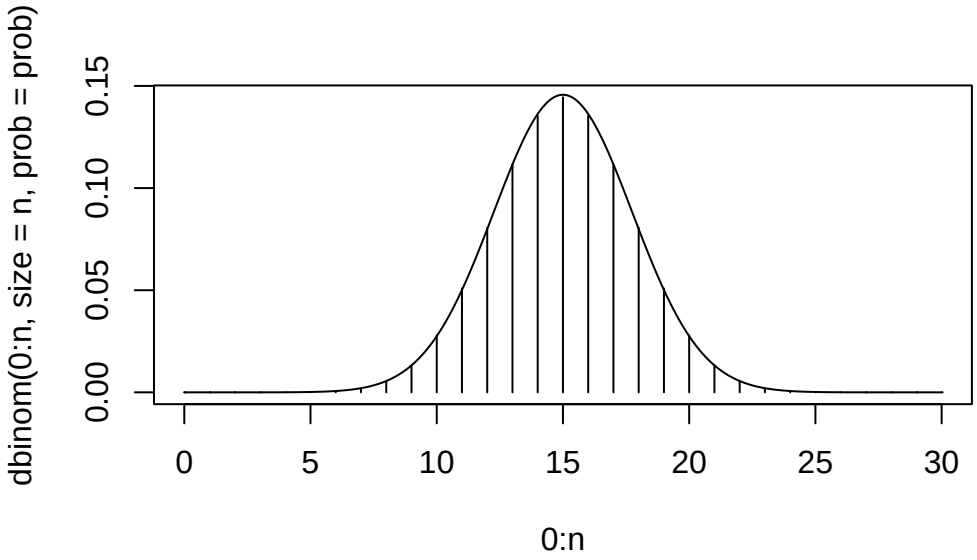


Add some default values

```
plot_norm_approx <- function(n = 30, prob = 0.5){
  plot(0:n, dbinom(0:n, size = n, prob = prob),
     type = "h") #type h for histogram
  #plot normal distribution
  norm_x <- seq(from = 0, to = n, length = 1000)
  lines(norm_x,
        dnorm(norm_x,
              mean = n*prob,
              sd = sqrt(n*prob*(1-prob)))
        )
}
```

Test

```
plot_norm_approx()
```


dbinom(0:n, size = n, prob = prob)
0.00
0.05
0.10
0.15
0
5
10
15
20
25
30
0:n