Intro_to_R_2016_Code.R

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```
## Introduction to R
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############################################################
## R Basics
############################################################

## R can be used as a calculator, it works as expected:
2+3
```

```
## [1] 5
```

```
exp(2)
```

```
## [1] 7.389056
```

```
5^(2)
```

```
## [1] 25
```

```
3*2+4
```

```
## [1] 10
```

```
(2*4+1)/2
```

```
## [1] 4.5
```

```
## The print command:
print("Hello World")
```

```
## [1] "Hello World"
```

```
print(5*2-11)
```

```
## [1] -1
```

```
## Assigning a variable
x <- 5 # 5 has now been assigned to the variable x

# the "<-" assigns the value on the right to the name on the left. Made by "alt -"

x # Evaluation
```

```
## [1] 5
```

```
x^2
```

```
## [1] 25
```

```
## Creating a vector:
y <- c(3,7,5,1,2,3,2,5,5) # "c()" concatenates, creating a vector

## Extracting values of a vector:
y[2]
```

```
## [1] 7
```

```
3:5 # the whole numbers from 3 to 5
```

```
## [1] 3 4 5
```

```
y[3:5] # extracts the 3rd to 5th elements in the vector y
```

```
## [1] 5 1 2
```

```
sub.y <- y[3:5]
sub.y
```

```
## [1] 5 1 2
```

```
## Value Comparison
2==2  # Equality
```

```
## [1] TRUE
```

```
2!=2  # Inequality
```

```
## [1] FALSE
```

```
x <= y # less than or equal: "<", ">", and ">=" also work
```

```
## [1] FALSE  TRUE  TRUE FALSE FALSE FALSE FALSE  TRUE  TRUE
```

```
## Other ways to make vectors:
array(data = 0, dim = 3)
```

```
## [1] 0 0 0
```

```r
seq(from = 1, to = 4, by = 1)
```

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

```r
seq(1,4,0.5)
```

```
## [1] 1.0 1.5 2.0 2.5 3.0 3.5 4.0
```

```r
rep(x = "cat", times = 3)
```

```
## [1] "cat" "cat" "cat"
```

```r
rep(c("cat", 4, x^(2)), each = 2)
```

```
## [1] "cat" "cat" "4"   "4"   "25"  "25"
```

```r
rep(c("cat", 4, x^(2)), times = 2)
```

```
## [1] "cat" "4"   "25"  "cat" "4"   "25"
```

```r
## "matrix()" creates a matrix from the values entered:
z <- matrix(y, nrow=3) # This is filled by column
z
```

```
##      [,1] [,2] [,3]
## [1,]    3    1    2
## [2,]    7    2    5
## [3,]    5    3    5
```

```r
z <- matrix(y, nrow=3, byrow=T)
# By changing the "byrow" option, we can fill the matrix by row
z
```

```
##      [,1] [,2] [,3]
## [1,]    3    7    5
## [2,]    1    2    3
## [3,]    2    5    5
```

```r
## Extracting values from matrices:
z[2,] # Row
```

```
## [1] 1 2 3
```

```r
z[,3] # Column
```

```
## [1] 5 3 5
```

```r
z[2,3] # Value
```

```
## [1] 3
```

```r
## Other ways to make matrics:
array(data = y, dim = c(3,3))
```

```
##      [,1] [,2] [,3]
## [1,]    3    1    2
## [2,]    7    2    5
## [3,]    5    3    5
```

```r
matrix(c(1,2,3,4,5,6), nrow = 2)
```

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

```r
## Create Dataframes:
dat <- as.data.frame(z)
names(dat) <- c("cat", "giraffe","bowlingball")
dat
```

```
##   cat giraffe bowlingball
## 1   3       7          5
## 2   1       2          3
## 3   2       5          5
```

```r
dat2 <- data.frame( ID=1:4,
                    FirstName=c("Batman","Robin","Ivy","Joker"),
                    Female=c(F,F,T,F),
                    Age=c(22,33,44,55) )

dat2$FirstName   # Access the second column of dfr1.
```

```
## [1] Batman Robin  Ivy    Joker
## Levels: Batman Ivy Joker Robin
```

```r
## R has base functions:
mean(y)
```

```
## [1] 3.666667
```

```r
length(y)
```

```
## [1] 9
```

```r
sd(y)
```

```
## [1] 1.936492
```

```r
var(y)
```

```
## [1] 3.75
```

```r
prod(y) # Takes the product of each element in the vector
```

```
## [1] 31500
```

```r
cor(z)
```

```
##           [,1]      [,2]      [,3]
## [1,] 1.0000000 0.9933993 0.8660254
## [2,] 0.9933993 1.0000000 0.9176629
## [3,] 0.8660254 0.9176629 1.0000000
```

```r
apply(z, 2, mean) # Very useful in avoiding for loops, also has useful cousins sapply and lapply
```

```
## [1] 2.000000 4.666667 4.333333
```

```r
############################################################
## Introduction to Statistics with R
############################################################

## Getting help
# help.start()  # Opens html help in web browser (if installed)
# help(help)    # find help on how to use help
# ?help     # Same as above
# help.search("help")   # Find all functions that include the word 'help'

## Getting help on particular functions:
help(plot) # You can use the help function, the argument is an R function
?plot # or just a question mark in front of the funtion you have questions about


## Reading in your data
getwd()               # What directory are we in?
```

```
## [1] "/Users/breannechryst/IntroductionToR2016"
```

```r
# R will read and write files to the working directory, unless otherwise specified
setwd("~/IntroductionToR2016")  # You can change your working directory

## Read in data from the web
dat <- read.table("http://www.stat.yale.edu/~blc3/IntroR2016/remote_weight.txt",
                  header=T, sep="", row.names=NULL, as.is = TRUE)
```

```
## Read in Data from local folder
dat <- read.table("~/IntroductionToR2016/remote_weight.txt",
                  header=T, sep="", as.is = TRUE)

# Read data including headers, data separated by spaces, no row names
ls()                       # List all variables stored in memory
```

```
## [1] "dat"   "dat2"  "sub.y" "x"     "y"     "z"
```

```
head(dat)           # Shows the first 6 rows of the data
```

```
##   id remote weight gender group
## 1  1      5    151      0     1
## 2  2      7    152      0     2
## 3  3      3    153      0     1
## 4  4      2    165      0     2
## 5  5      5    138      0     1
## 6  6      0    149      0     2
```

```
head(dat, 10)       # the first 10 rows of the data
```

```
##    id remote weight gender group
## 1   1      5    151      0     1
## 2   2      7    152      0     2
## 3   3      3    153      0     1
## 4   4      2    165      0     2
## 5   5      5    138      0     1
## 6   6      0    149      0     2
## 7   7      5    142      0     1
## 8   8      9    139      0     2
## 9   9      1    140      0     2
## 10 10      8    138      0     1
```

```
tail(dat)           # last 6 rows of the data
```

```
##      id remote weight gender group
## 95   95     30    167      1     1
## 96   96     28    154      1     1
## 97   97     29    181      1     1
## 98   98     34    172      1     1
## 99   99     23    159      1     2
## 100 100     25    177      1     1
```

```
## Extracting data from the data frame
dim(dat)              # Find out how many rows and columns in the data set
```

```
## [1] 100   5
```

```r
names(dat)          # List all variable names in the dataset
```

```
## [1] "id"     "remote" "weight" "gender" "group"
```

```r
str(dat)            # Look at the structure of your data
```

```
## 'data.frame':    100 obs. of  5 variables:
##  $ id    : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ remote: int  5 7 3 2 5 0 5 9 1 8 ...
##  $ weight: int  151 152 153 165 138 149 142 139 140 138 ...
##  $ gender: int  0 0 0 0 0 0 0 0 0 0 ...
##  $ group : int  1 2 1 2 1 2 1 2 2 1 ...
```

```r
dat                   # See the data frame on the screen
```

```
##       id remote weight gender group
## 1      1      5    151      0     1
## 2      2      7    152      0     2
## 3      3      3    153      0     1
## 4      4      2    165      0     2
## 5      5      5    138      0     1
## 6      6      0    149      0     2
## 7      7      5    142      0     1
## 8      8      9    139      0     2
## 9      9      1    140      0     2
## 10    10      8    138      0     1
## 11    11      7    137      0     1
## 12    12      7    119      0     1
## 13    13      8    140      0     2
## 14    14      9    145      0     1
## 15    15      5    126      0     2
## 16    16      3    142      0     2
## 17    17      6    127      0     2
## 18    18     10    135      0     1
## 19    19      7    149      0     2
## 20    20      7    134      0     2
## 21    21      5    157      0     2
## 22    22      7    141      0     2
## 23    23      4    146      0     2
## 24    24      8    127      0     1
## 25    25      1    143      0     2
## 26    26      4    151      0     2
## 27    27      8    132      0     1
## 28    28      2    149      0     1
## 29    29      0    144      0     2
## 30    30      5    148      0     1
## 31    31      2    119      0     2
## 32    32      9    129      0     2
## 33    33      8    138      0     2
## 34    34      1    165      0     1
## 35    35     10    142      0     1
## 36    36      8    138      0     1
```

```
## 37   37       5    137       0      2
## 38   38       9    154       0      1
## 39   39       1    133       0      1
## 40   40       9    139       0      2
## 41   41       2    146       0      2
## 42   42       9    152       0      1
## 43   43       7    149       0      2
## 44   44      10    128       0      2
## 45   45       8    131       0      1
## 46   46       4    136       0      2
## 47   47       1    148       0      2
## 48   48       4    134       0      2
## 49   49       1    137       0      1
## 50   50       4    137       0      1
## 51   51      31    159       1      2
## 52   52      32    167       1      2
## 53   53      27    175       1      1
## 54   54      37    189       1      1
## 55   55      28    179       1      1
## 56   56      27    145       1      1
## 57   57      30    161       1      2
## 58   58      35    181       1      2
## 59   59      31    177       1      1
## 60   60      27    178       1      2
## 61   61      26    170       1      2
## 62   62      31    158       1      1
## 63   63      32    179       1      1
## 64   64      37    192       1      1
## 65   65      35    183       1      2
## 66   66      31    184       1      1
## 67   67      29    169       1      1
## 68   68      34    182       1      2
## 69   69      30    190       1      1
## 70   70      30    195       1      2
## 71   71      35    182       1      2
## 72   72      30    174       1      1
## 73   73      37    184       1      2
## 74   74      29    188       1      2
## 75   75      23    150       1      1
## 76   76      31    178       1      1
## 77   77      35    186       1      2
## 78   78      28    170       1      1
## 79   79      21    149       1      1
## 80   80      33    203       1      2
## 81   81      27    172       1      2
## 82   82      23    160       1      2
## 83   83      36    179       1      2
## 84   84      30    195       1      1
## 85   85      32    160       1      1
## 86   86      20    147       1      1
## 87   87      22    144       1      2
## 88   88      35    178       1      1
## 89   89      34    168       1      1
## 90   90      27    157       1      1
```

```
## 91   91     34    184      1     1
## 92   92     18    133      1     2
## 93   93     31    160      1     1
## 94   94     29    170      1     2
## 95   95     30    167      1     1
## 96   96     28    154      1     1
## 97   97     29    181      1     1
## 98   98     34    172      1     1
## 99   99     23    159      1     2
## 100 100     25    177      1     1
```

```
dat[1:10,]          # See the first 10 rows
```

```
##    id remote weight gender group
## 1   1      5    151      0     1
## 2   2      7    152      0     2
## 3   3      3    153      0     1
## 4   4      2    165      0     2
## 5   5      5    138      0     1
## 6   6      0    149      0     2
## 7   7      5    142      0     1
## 8   8      9    139      0     2
## 9   9      1    140      0     2
## 10 10      8    138      0     1
```

```
dat[,"weight"]      # See only the weight column
```

```
##   [1] 151 152 153 165 138 149 142 139 140 138 137 119 140 145 126 142 127
##  [18] 135 149 134 157 141 146 127 143 151 132 149 144 148 119 129 138 165
##  [35] 142 138 137 154 133 139 146 152 149 128 131 136 148 134 137 137 159
##  [52] 167 175 189 179 145 161 181 177 178 170 158 179 192 183 184 169 182
##  [69] 190 195 182 174 184 188 150 178 186 170 149 203 172 160 179 195 160
##  [86] 147 144 178 168 157 184 133 160 170 167 154 181 172 159 177
```

```
dat[,3]             # Same as above
```

```
##   [1] 151 152 153 165 138 149 142 139 140 138 137 119 140 145 126 142 127
##  [18] 135 149 134 157 141 146 127 143 151 132 149 144 148 119 129 138 165
##  [35] 142 138 137 154 133 139 146 152 149 128 131 136 148 134 137 137 159
##  [52] 167 175 189 179 145 161 181 177 178 170 158 179 192 183 184 169 182
##  [69] 190 195 182 174 184 188 150 178 186 170 149 203 172 160 179 195 160
##  [86] 147 144 178 168 157 184 133 160 170 167 154 181 172 159 177
```

```
dat$weight          # Yet another way
```

```
##   [1] 151 152 153 165 138 149 142 139 140 138 137 119 140 145 126 142 127
##  [18] 135 149 134 157 141 146 127 143 151 132 149 144 148 119 129 138 165
##  [35] 142 138 137 154 133 139 146 152 149 128 131 136 148 134 137 137 159
##  [52] 167 175 189 179 145 161 181 177 178 170 158 179 192 183 184 169 182
##  [69] 190 195 182 174 184 188 150 178 186 170 149 203 172 160 179 195 160
##  [86] 147 144 178 168 157 184 133 160 170 167 154 181 172 159 177
```

```r
dat[1:10,"weight"]  # See only the first 10 values of the weight col.
```

```
##  [1] 151 152 153 165 138 149 142 139 140 138
```

```r
dat[,-1]              # See all but the first column of data
```

```
##     remote weight gender group
## 1        5    151      0     1
## 2        7    152      0     2
## 3        3    153      0     1
## 4        2    165      0     2
## 5        5    138      0     1
## 6        0    149      0     2
## 7        5    142      0     1
## 8        9    139      0     2
## 9        1    140      0     2
## 10       8    138      0     1
## 11       7    137      0     1
## 12       7    119      0     1
## 13       8    140      0     2
## 14       9    145      0     1
## 15       5    126      0     2
## 16       3    142      0     2
## 17       6    127      0     2
## 18      10    135      0     1
## 19       7    149      0     2
## 20       7    134      0     2
## 21       5    157      0     2
## 22       7    141      0     2
## 23       4    146      0     2
## 24       8    127      0     1
## 25       1    143      0     2
## 26       4    151      0     2
## 27       8    132      0     1
## 28       2    149      0     1
## 29       0    144      0     2
## 30       5    148      0     1
## 31       2    119      0     2
## 32       9    129      0     2
## 33       8    138      0     2
## 34       1    165      0     1
## 35      10    142      0     1
## 36       8    138      0     1
## 37       5    137      0     2
## 38       9    154      0     1
## 39       1    133      0     1
## 40       9    139      0     2
## 41       2    146      0     2
## 42       9    152      0     1
## 43       7    149      0     2
## 44      10    128      0     2
## 45       8    131      0     1
```

```
## 46       4    136       0      2
## 47       1    148       0      2
## 48       4    134       0      2
## 49       1    137       0      1
## 50       4    137       0      1
## 51      31    159       1      2
## 52      32    167       1      2
## 53      27    175       1      1
## 54      37    189       1      1
## 55      28    179       1      1
## 56      27    145       1      1
## 57      30    161       1      2
## 58      35    181       1      2
## 59      31    177       1      1
## 60      27    178       1      2
## 61      26    170       1      2
## 62      31    158       1      1
## 63      32    179       1      1
## 64      37    192       1      1
## 65      35    183       1      2
## 66      31    184       1      1
## 67      29    169       1      1
## 68      34    182       1      2
## 69      30    190       1      1
## 70      30    195       1      2
## 71      35    182       1      2
## 72      30    174       1      1
## 73      37    184       1      2
## 74      29    188       1      2
## 75      23    150       1      1
## 76      31    178       1      1
## 77      35    186       1      2
## 78      28    170       1      1
## 79      21    149       1      1
## 80      33    203       1      2
## 81      27    172       1      2
## 82      23    160       1      2
## 83      36    179       1      2
## 84      30    195       1      1
## 85      32    160       1      1
## 86      20    147       1      1
## 87      22    144       1      2
## 88      35    178       1      1
## 89      34    168       1      1
## 90      27    157       1      1
## 91      34    184       1      1
## 92      18    133       1      2
## 93      31    160       1      1
## 94      29    170       1      2
## 95      30    167       1      1
## 96      28    154       1      1
## 97      29    181       1      1
## 98      34    172       1      1
## 99      23    159       1      2
```

```
## 100     25    177      1     1
```

```
dat.o <- dat        # Copy the data frame to a data.frame named dat.O
ls()                      # Now we have 5 variables: 'x', 'y', 'z', 'dat' and 'dat.o'
```

```
## [1] "dat"   "dat.o" "dat2"  "sub.y" "x"     "y"     "z"
```

```
table(dat$group)
```

```
##
##  1  2
## 51 49
```

```
## Getting familiar with the data
summary(dat)            # Generate summary statistics of data
```

```
##        id              remote          weight          gender
##  Min.   :  1.00   Min.   : 0.00   Min.   :119.0   Min.   :0.0
##  1st Qu.: 25.75   1st Qu.: 5.00   1st Qu.:139.8   1st Qu.:0.0
##  Median : 50.50   Median :14.00   Median :152.0   Median :0.5
##  Mean   : 50.50   Mean   :17.59   Mean   :156.4   Mean   :0.5
##  3rd Qu.: 75.25   3rd Qu.:30.00   3rd Qu.:174.2   3rd Qu.:1.0
##  Max.   :100.00   Max.   :37.00   Max.   :203.0   Max.   :1.0
##      group
##  Min.   :1.00
##  1st Qu.:1.00
##  Median :1.00
##  Mean   :1.49
##  3rd Qu.:2.00
##  Max.   :2.00
```

```
apply(dat, 2, sd)   # Calculate standard deviations of all variables
```

```
##         id     remote     weight     gender      group
## 29.0114920 12.8488454 20.0833491  0.5025189  0.5024184
```

```
var(dat)                # Variance on diagonal, covariance off diagonal
```

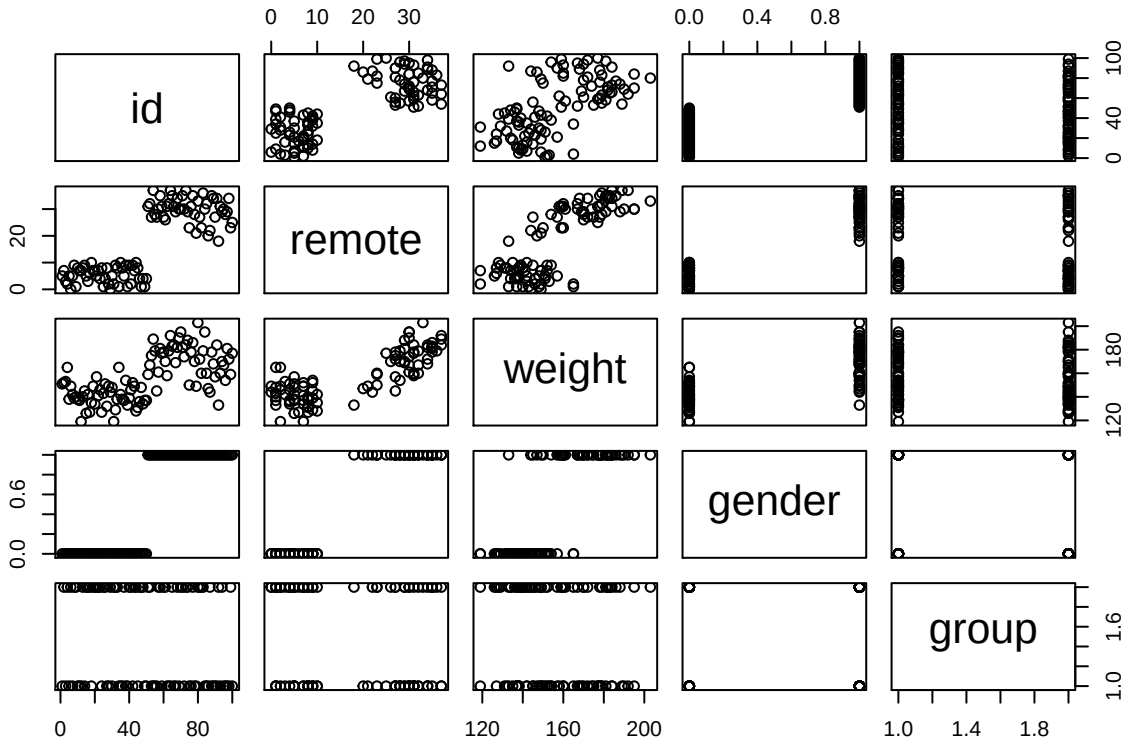
```
##                id      remote      weight      gender       group
## id     841.666667 299.2878788 355.6919192 12.62626263 -2.24747475
## remote 299.287879 165.0928283 209.4489899  6.15656566 -0.98898990
## weight 355.691919 209.4489899 403.3409091  7.79292929 -0.82878788
## gender  12.626263   6.1565657   7.7929293  0.25252525 -0.03535354
## group   -2.247475  -0.9889899  -0.8287879 -0.03535354  0.25242424
```

```
mean(dat)             # Calculate the mean of all variables
```

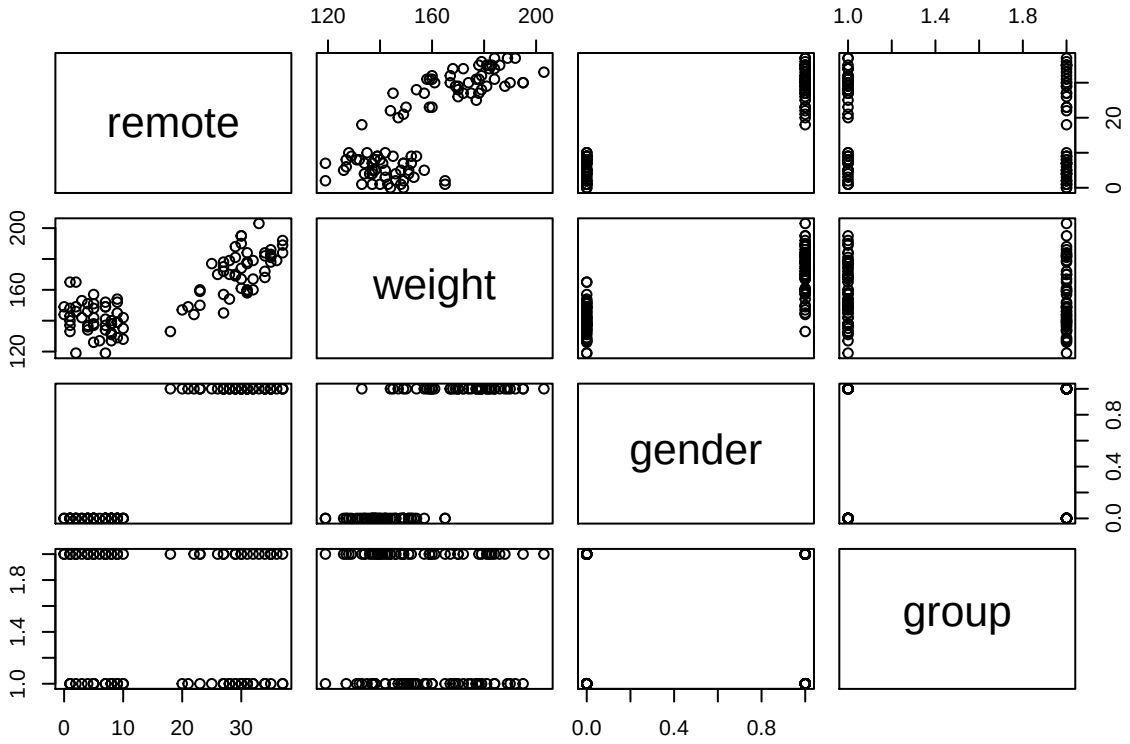
```
## Warning in mean.default(dat): argument is not numeric or logical: returning
## NA
```

```
## [1] NA
```

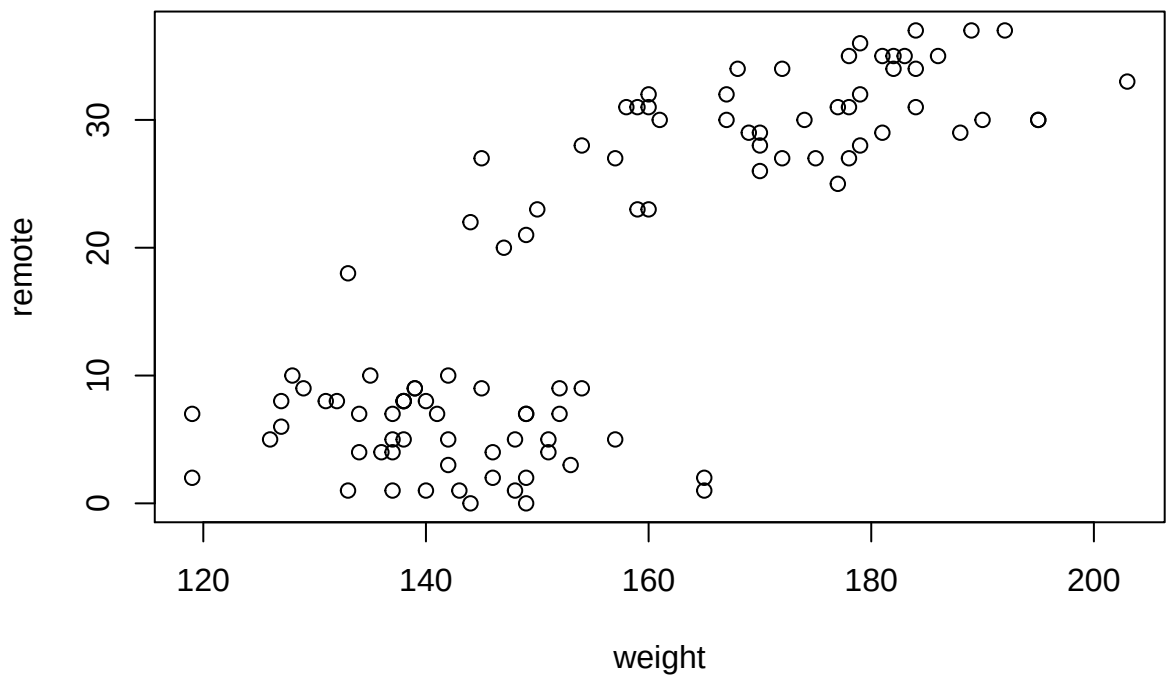
```r
pairs(dat)              # A general view of data through scatter plots
```




```r
pairs(dat[,-1])
```



```
# See scatterplots for all pairs of variables except the first ('id') in the data frame
plot(remote ~ weight, data = dat)   # Scatterplot of 'weight' vs. 'remote'
```




```
## Changing data type
class(dat$gender)  # What kind of variable is 'gender'?
```

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

```
dat$gender <- factor(dat$gender)    # Converts 'gender' from type integer to factor
class(dat$gender)   # Verify that gender is now indeed of type factor
```

```
## [1] "factor"
```

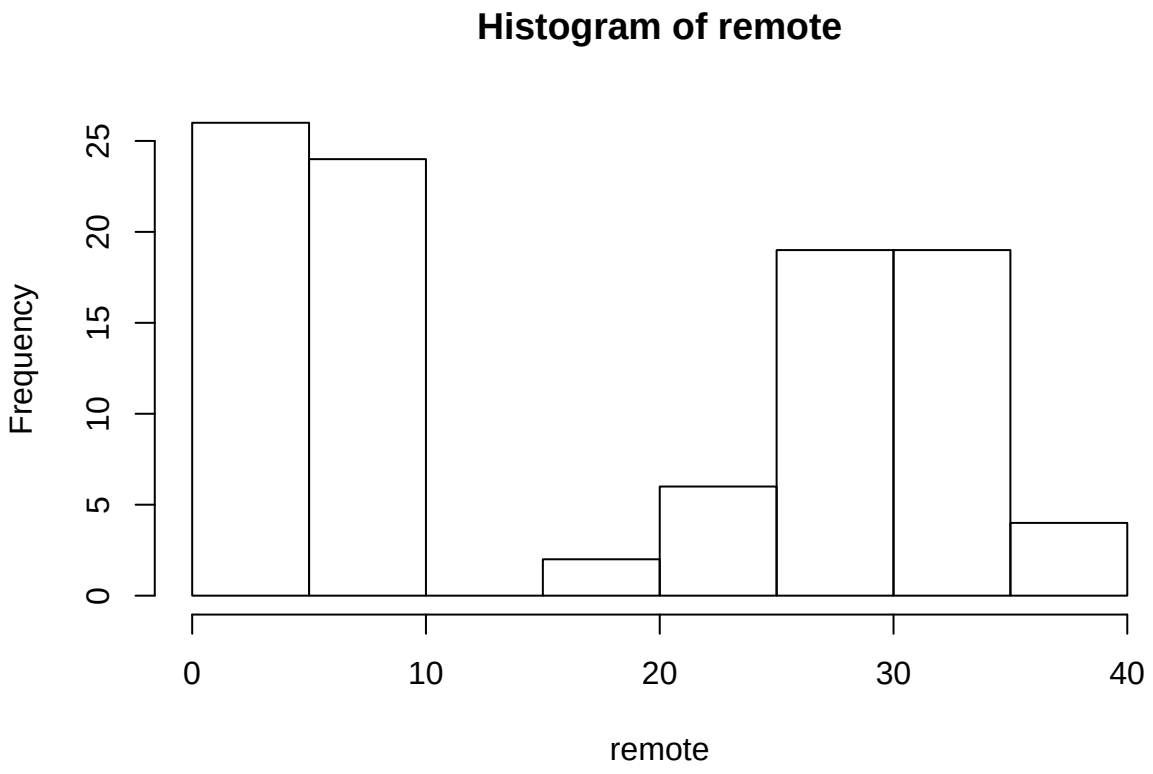
```
dat$gender              # See all data in column 'gender'; note "Levels: 0 1" at the bottom
```

```
##   [1] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
##  [36] 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
##  [71] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## Levels: 0 1
```

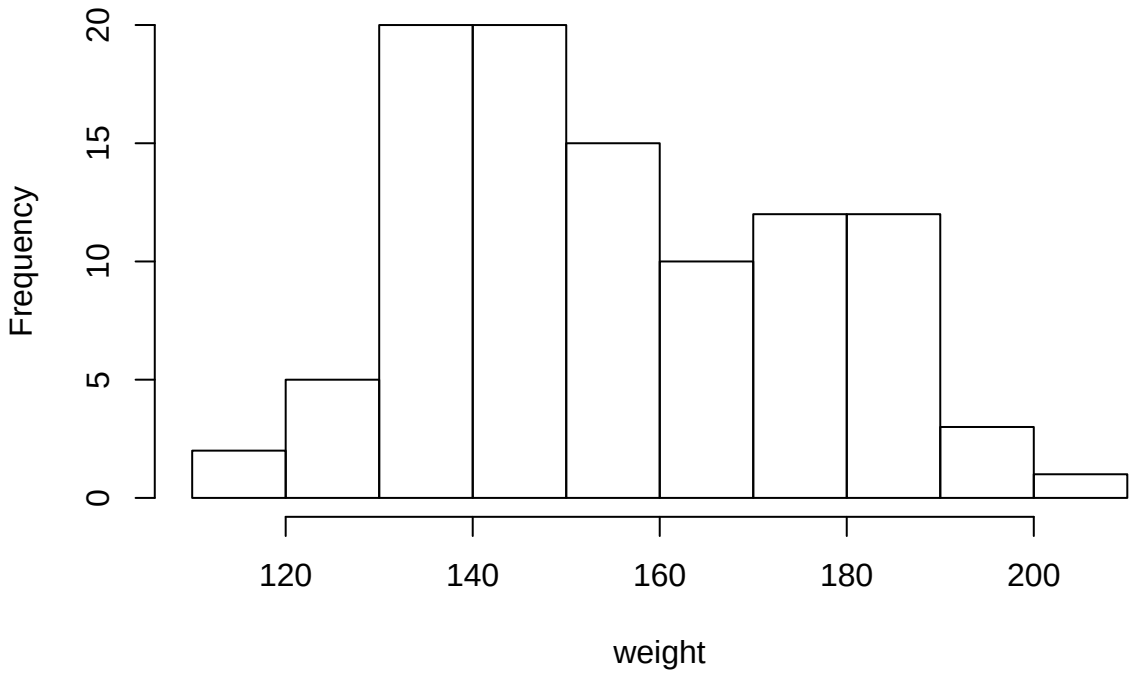
```
## Attaching the data frame
attach(dat)         # Attach the data frame
remote                  # Now we can refer directly to the variable without using $
```

```
##   [1]  5  7  3  2  5  0  5  9  1  8  7  7  8  9  5  3  6 10  7  7  5  7  4
##  [24]  8  1  4  8  2  0  5  2  9  8  1 10  8  5  9  1  9  2  9  7 10  8  4
##  [47]  1  4  1  4 31 32 27 37 28 27 30 35 31 27 26 31 32 37 35 31 29 34 30
##  [70] 30 35 30 37 29 23 31 35 28 21 33 27 23 36 30 32 20 22 35 34 27 34 18
##  [93] 31 29 30 28 29 34 23 25
```

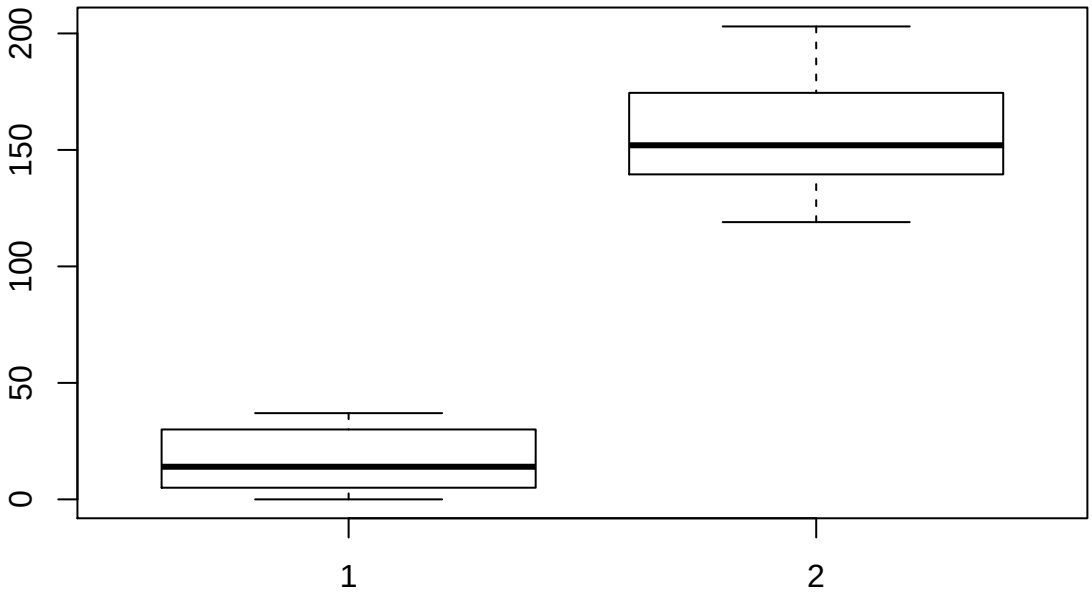
```r
## Basic Graphics
hist(remote)                # Histogram of 'remote'
```



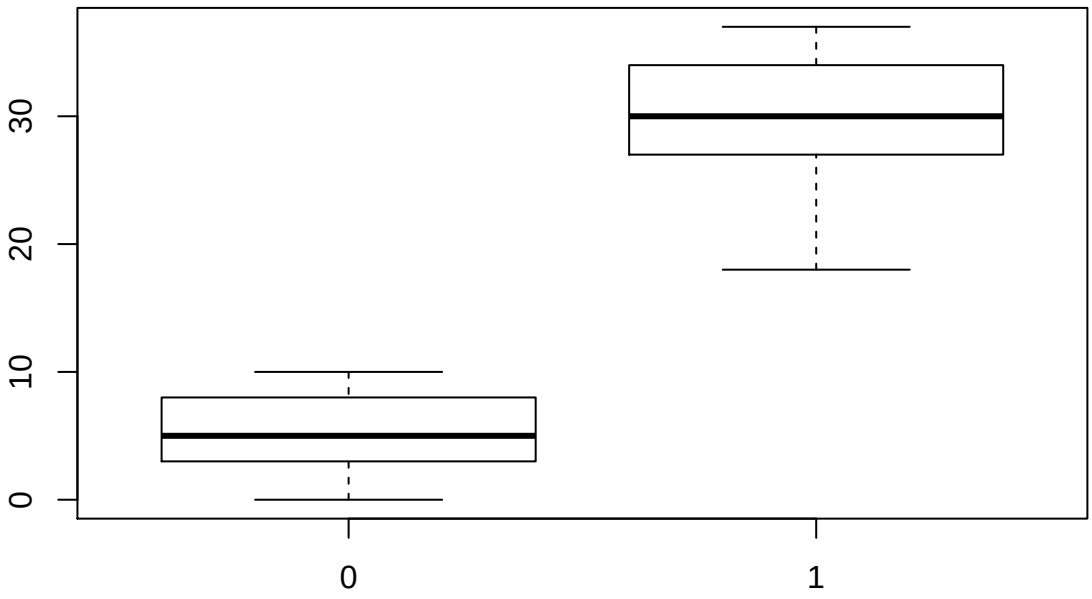

```r
hist(weight)                # Histogram of 'weight'
```



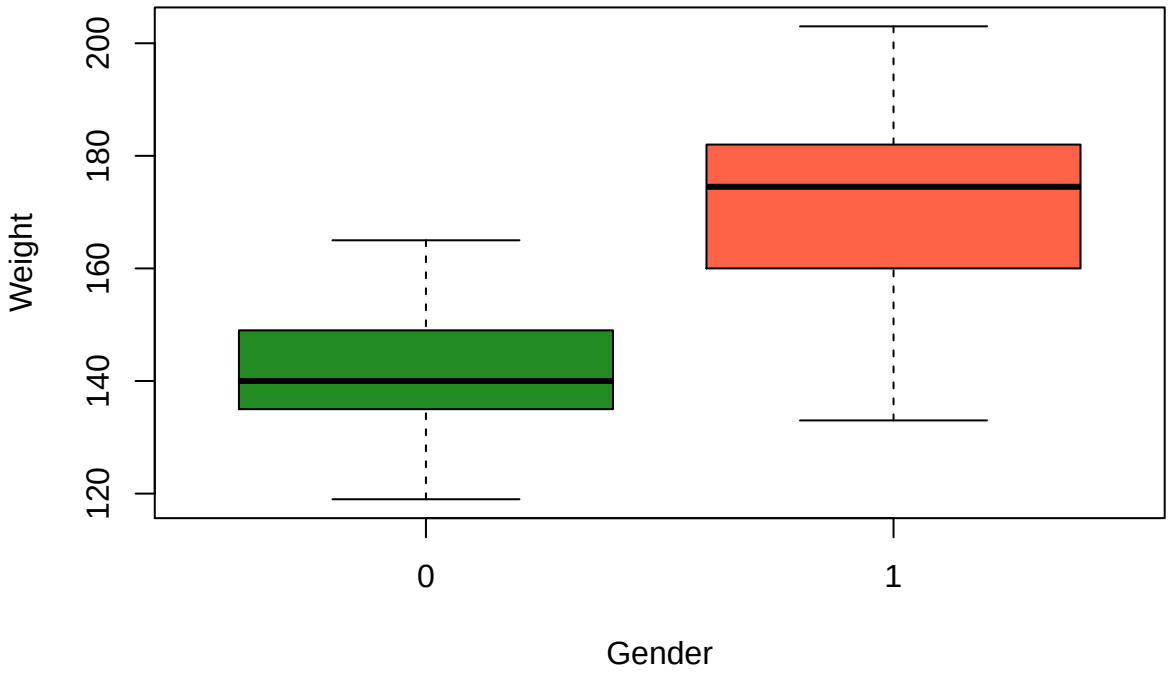
```r
boxplot(remote,weight)        # Boxplot of 'remote' and 'weight'
```




```r
boxplot(remote ~ gender)    # Boxplot of 'remote' conditioned on 'gender'
```




```r
boxplot(weight ~ gender, main = "Weight by Gender",
        xlab = "Gender", ylab = "Weight",
        col = c("forestgreen", "tomato"))   # Boxplot of 'weight' conditioned on 'gender'
```




```
## Inferential statistics
cor(remote,weight)                # Run correlation coefficient
```

```
## [1] 0.8116673
```

```
t.test(remote ~ gender)          # Did frequency of remote use differ by gender?
```

```
##
##  Welch Two Sample t-test
##
## data:  remote by gender
## t = -31.32, df = 84.845, p-value < 2.2e-16
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -25.92777 -22.83223
## sample estimates:
## mean in group 0 mean in group 1
##            5.40           29.78
```

```
rem.t <- t.test(remote ~ gender)# Save results of last analysis
rem.t                           # Display analysis
```

```
##
##  Welch Two Sample t-test
##
## data:  remote by gender
## t = -31.32, df = 84.845, p-value < 2.2e-16
```

```
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -25.92777 -22.83223
## sample estimates:
## mean in group 0 mean in group 1
##            5.40           29.78
```

```
names(rem.t)                # See the names of variables in the object rem.t
```

```
## [1] "statistic"   "parameter"   "p.value"     "conf.int"    "estimate"
## [6] "null.value"  "alternative" "method"      "data.name"
```

```
rem.t$statistic          # See the statistics variable in the object rem.t
```

```
##         t
## -31.31951
```

```
mod1 <- lm(remote ~ gender)     # Linear model, regressing 'remote' on 'gender'
anova(mod1)               # ANOVA table of the previous model
```

```
## Analysis of Variance Table
##
## Response: remote
##           Df  Sum Sq Mean Sq F value    Pr(>F)
## gender     1 14859.6 14859.6  980.91 < 2.2e-16 ***
## Residuals 98  1484.6    15.1
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(lm(remote ~ gender))      # You can combine the two steps in to one line
```

```
## Analysis of Variance Table
##
## Response: remote
##           Df  Sum Sq Mean Sq F value    Pr(>F)
## gender     1 14859.6 14859.6  980.91 < 2.2e-16 ***
## Residuals 98  1484.6    15.1
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
mod2 <- lm(remote ~ weight)     # Model 'remote' as a linear function of 'weight'
mod3 <- lm(remote ~ weight + gender)  # Model 'remote' as a linear function of 'weight' & 'gender'
mod4 <- lm(remote ~ weight*gender)
# Equivalent to all main effects and interaction:
# lm(remote ~ weight + gender + weight*gender)
summary(mod3)             # See regression table for model 3 (remote ~ weight + gender)
```

```
##
## Call:
## lm(formula = remote ~ weight + gender)
```

```
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -7.2651 -2.6495  0.1842  2.9608  6.1556
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -11.44900    4.02622  -2.844  0.00544 **
## weight        0.11948    0.02832   4.219 5.53e-05 ***
## gender1      20.69286    1.13190  18.282  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.596 on 97 degrees of freedom
## Multiple R-squared:  0.9232, Adjusted R-squared:  0.9217
## F-statistic: 583.4 on 2 and 97 DF,  p-value: < 2.2e-16
```

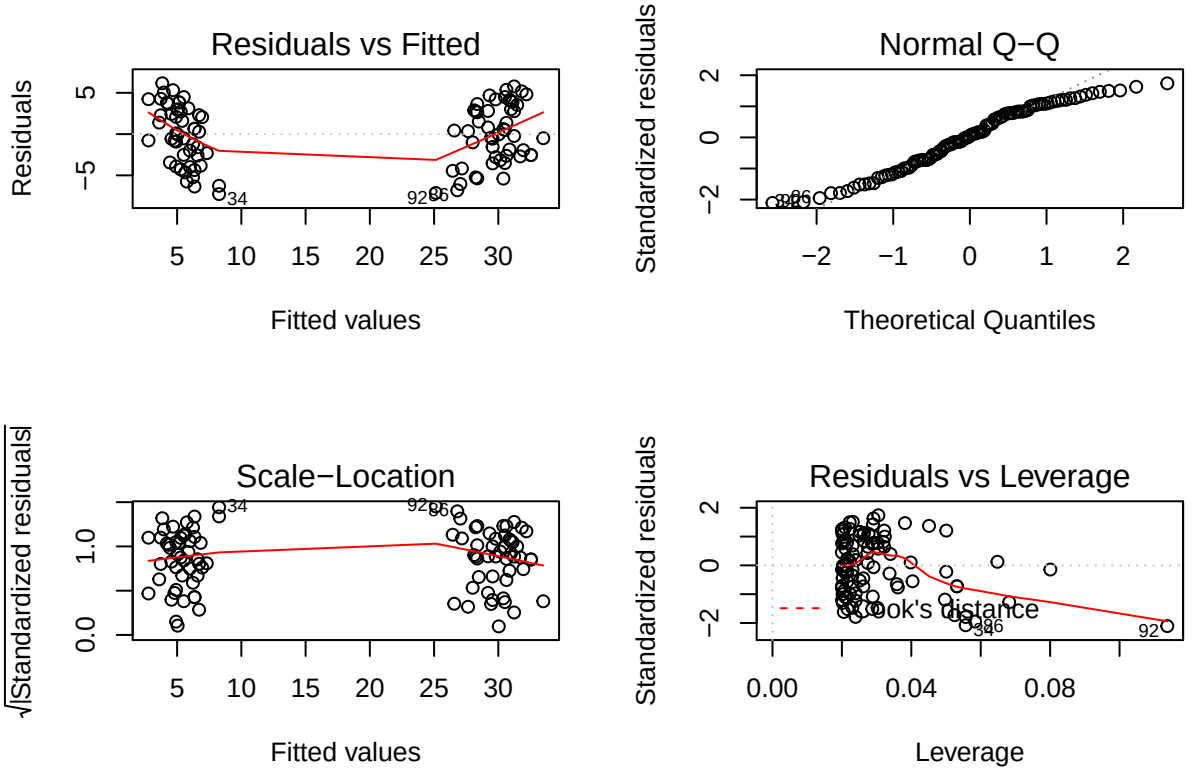
```
summary(mod4)              # See regression table for model 4 (remote ~ weight*gender)
```

```
##
## Call:
## lm(formula = remote ~ weight * gender)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -5.8530 -2.7707  0.0422  2.5473  5.0332
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)     16.72442    6.32943   2.642  0.00962 **
## weight          -0.08030    0.04477  -1.794  0.07601 .
## gender1        -22.96669    8.18338  -2.807  0.00606 **
## weight:gender1   0.28988    0.05393   5.375 5.36e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.169 on 96 degrees of freedom
## Multiple R-squared:  0.941,  Adjusted R-squared:  0.9392
## F-statistic: 510.4 on 3 and 96 DF,  p-value: < 2.2e-16
```

```
anova(mod3,mod4)         # Prints ANOVA table comparing model 3 to model 4 (delta F)
```

```
## Analysis of Variance Table
##
## Model 1: remote ~ weight + gender
## Model 2: remote ~ weight * gender
##   Res.Df     RSS Df Sum of Sq      F    Pr(>F)
## 1     97 1254.43
## 2     96  964.23  1     290.2 28.893 5.359e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
## Regression diagnostics
mod3.1 <- lm(remote ~ weight + gender)
par(mfrow=c(2,2))        # Set up plotting region for a 2x2 grid
plot(mod3.1)               # Plot the regression diagnostics (R knows automatically to do this)
```




```r
## Saving the graphs as PDF
pdf("prettygraph.pdf")  # Turn on the PDF device and open a blank file called "prettygraph.ps"
plot(mod3.1)            # Plot the model
dev.off()               # Turn off the postscript device
```

```
## pdf
##   2
```

```r
## Chi-squared Test
chisq.test(gender, group)
```

```
##
##  Pearson's Chi-squared test with Yates' continuity correction
##
## data:  gender and group
## X-squared = 1.4406, df = 1, p-value = 0.23
```

```r
############################################################
## Intro to Simulation and Functions with R:
############################################################

## Create a vector of 12 random numbers drawn
```

```
## from a uniform distribution over the
## interval between 0 and 1:
z <- runif(12) # Generates 12 observations from Unif(0,1)

z
```

```
##  [1] 0.32920506 0.01898433 0.93448939 0.17891582 0.72237156 0.25391211
##  [7] 0.74287966 0.31849095 0.48836747 0.41196728 0.61525964 0.96487975
```

```
## We can see which of these is less than 0.5 with the expression "z < 0.5"
z < 0.5
```

```
##  [1]  TRUE  TRUE FALSE  TRUE FALSE  TRUE FALSE  TRUE  TRUE  TRUE FALSE
## [12] FALSE
```

```
## R identifies "True" with "1" and "False" with "0":
as.numeric(z < 0.5)
```

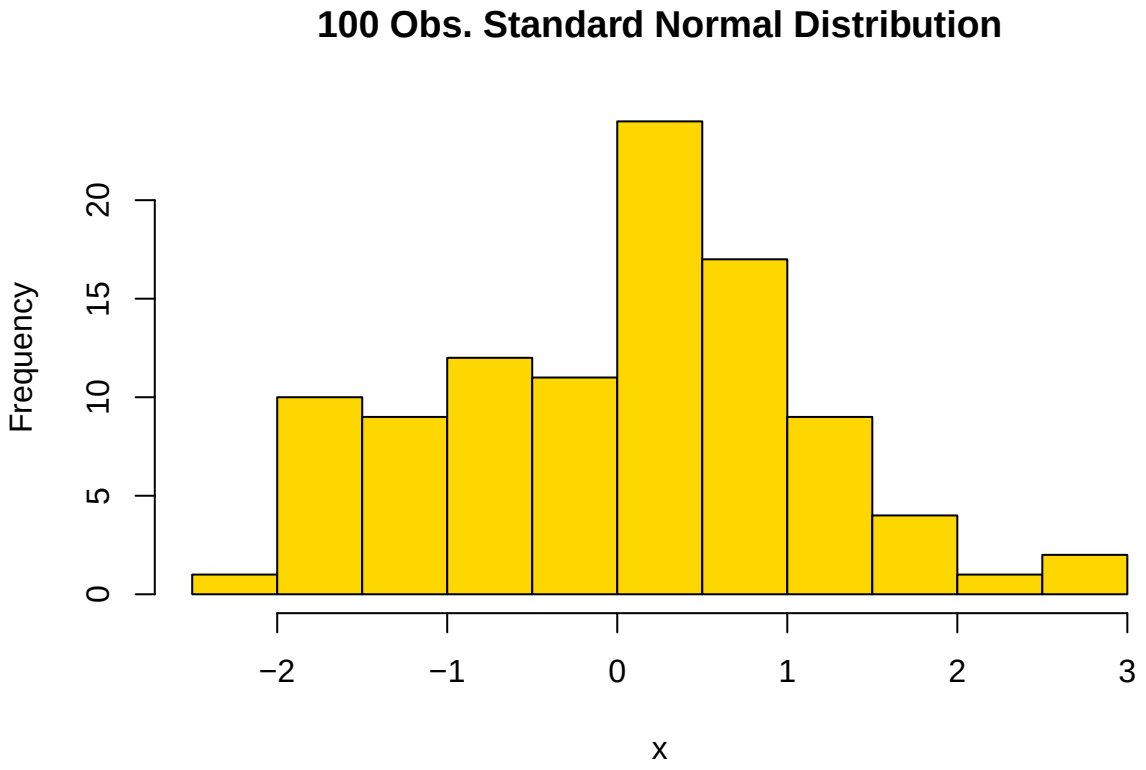
```
##  [1] 1 1 0 1 0 1 0 1 1 1 0 0
```

```
## Now let x be a vector of 100 random draws from a "Normal" distribution:
x <- rnorm(100) # Generates 100 random normal observations, mean 0 sd 1

x
```

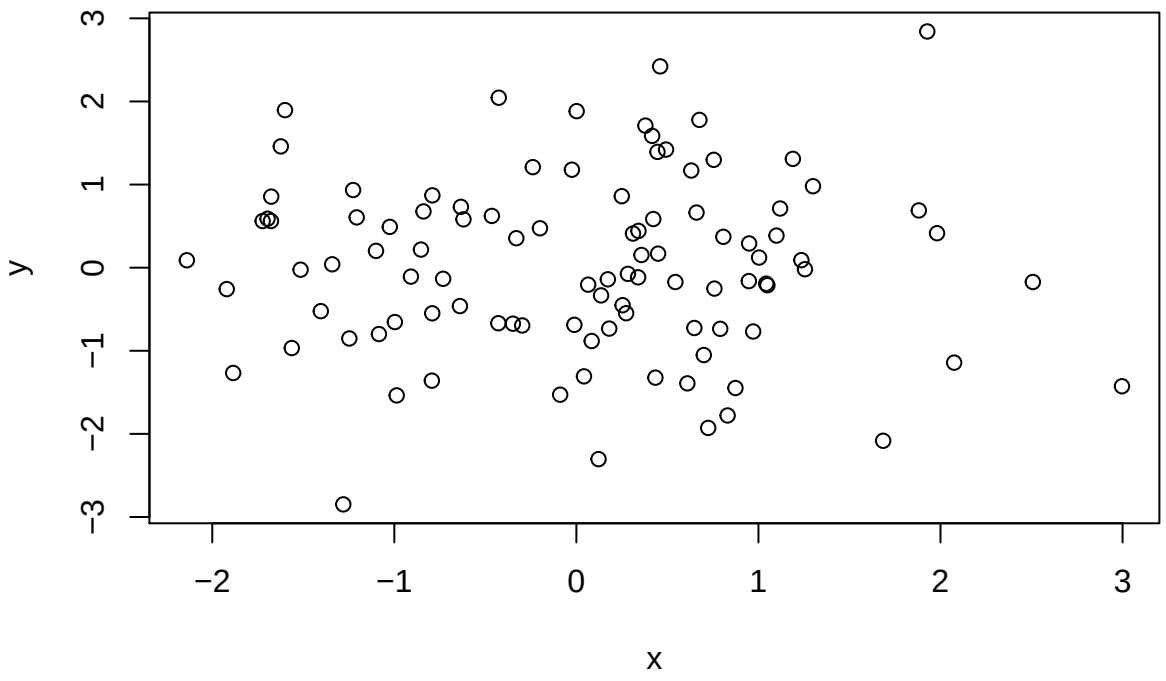
```
##   [1] -0.200012990  0.699899499 -0.634473933  0.416154334  0.433994724
##   [6]  0.445430480  2.996794402  0.273377078  0.357456419  0.249308401
##  [11] -0.464359559  1.003507969  1.927531225  0.121692878 -1.100580925
##  [16] -0.986996693 -2.139647225  0.311005285 -1.723198725 -1.084576056
##  [21] -1.600534489 -0.996953194  1.049249868  1.042735406  0.675760173
##  [26]  0.807134911 -1.226535930 -0.329891068  2.074956150 -1.514992320
##  [31] -1.247178265  0.754553589 -0.024590894 -0.426420647  0.422274596
##  [36]  2.507436861  0.379089438 -0.791699825 -1.563190554  0.971066600
##  [41] -0.297439399  0.492590133  0.172821605 -1.024842560  0.609668363
##  [46] -0.011182491  0.790143459  0.830592363 -0.791104395  0.631066770
##  [51]  0.253769031  1.119265811 -0.089011832 -0.908859200  0.339023467
##  [56]  0.948921148  0.543670492  1.685021014 -0.428554245  0.724072849
##  [61] -1.885117821  1.981072195  0.873651340  0.340941382 -0.639624283
##  [66]  0.283123119 -0.793733786 -1.676102155 -0.239291759  1.255400768
##  [71]  1.189128889 -0.839867776  0.460160596  1.235815951  1.880859914
##  [76]  0.041800470  0.001412153 -0.348594475 -1.696409877  0.758118115
##  [81]  1.098939376  0.648005729  0.947246546  0.180503543 -0.853632894
##  [86] -1.920442824 -1.623587718  0.135577859 -0.620126497  0.084125552
##  [91]  0.064757073  0.448736428 -1.206683863  0.659806255 -1.403913311
##  [96] -1.280328355 -1.341119429 -0.732032531 -1.677636407  1.299658320
```

```
par(mfrow=c(1,1)) #Resets the graphics to one plot per page
hist(x, main= "100 Obs. Standard Normal Distribution",
     breaks = 10, col = "gold") # Create a histogram of the vector x
```



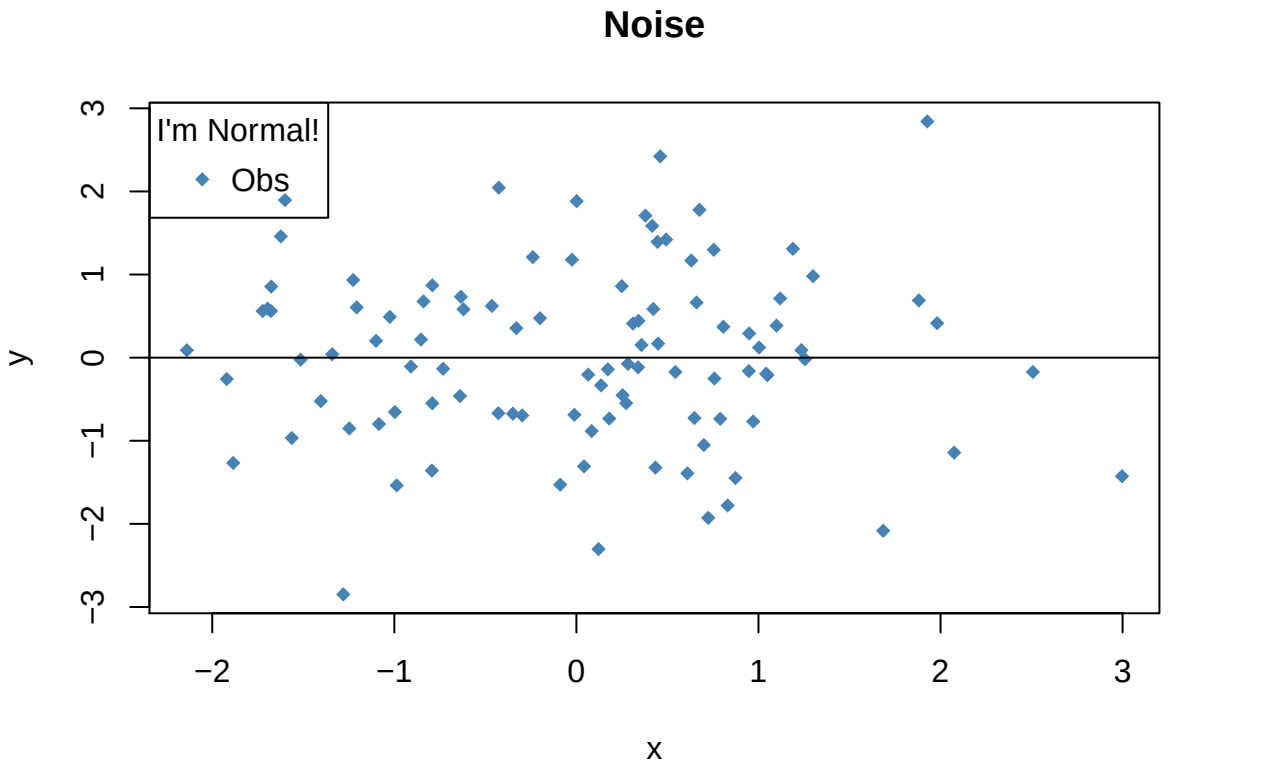

```r
y <- rnorm(100) # save 100 random sample from a standard normal distribution to y

plot(x,y)
```

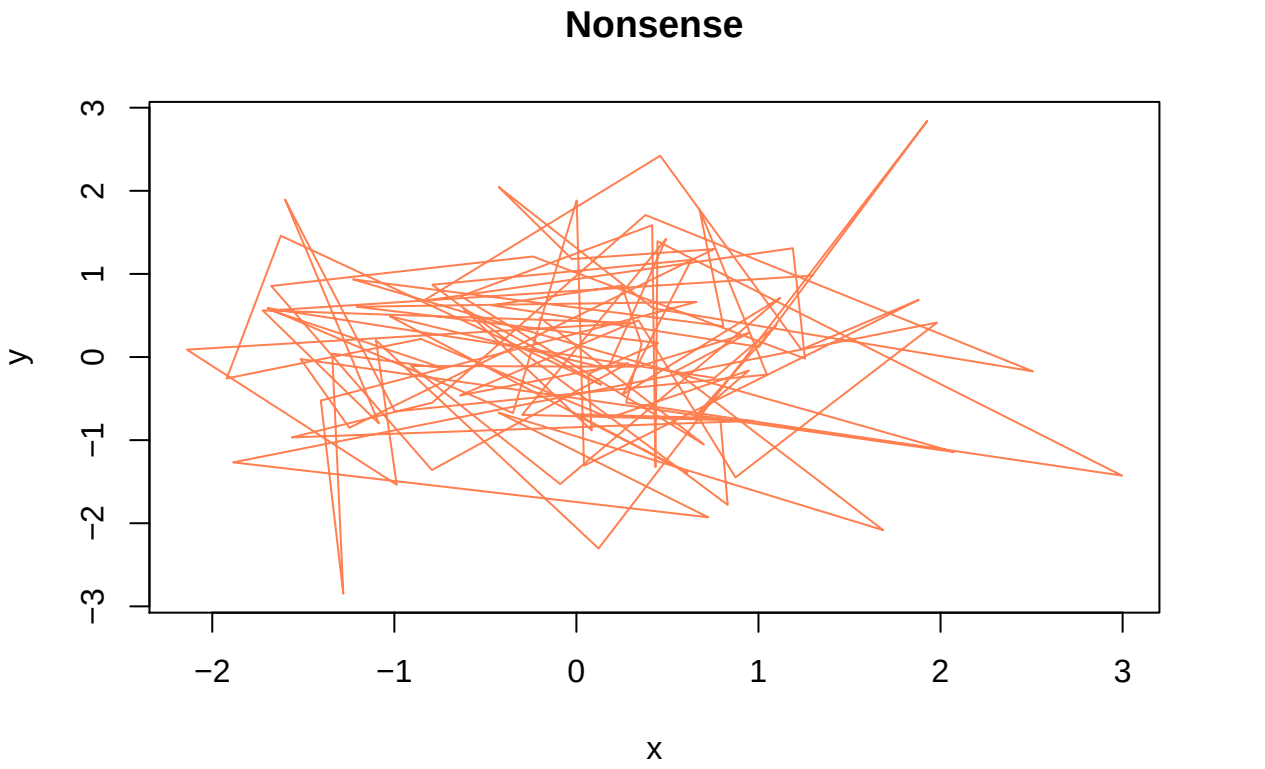



```r
plot(x,y,main = "Noise", col = "steelblue", pch = 18)
abline(h=0)
legend("topleft", title = "I'm Normal!", "Obs", pch= 18,
```

```
        col = "steelblue")
```




```
plot(x,y,type="l", main = "Nonsense", col = "coral")
```



```r
#?plot



# Sampling uniformly at random, with replacement
v <- sample(1:10,100,replace=T) # Samples from 1 to 10, 100 times

v
```

```
##   [1]  3  7  3  3  2  5  4 10  2  7  9  4  6  9  5  6  8 10  3 10  1  2  2
##  [24]  4 10 10  5  3  7  4  4  1  7  7  4  1  9 10  5  6 10  9  5 10  9  6
##  [47]  2 10  5  1 10 10  1  1  7  6  7  6  9 10  4  9  5  9  4  6  6  6  9
##  [70]  8  2  7 10  1  8  5  9  9  4  6 10  2  1  5  1  6  6  5  4  2  9  6
##  [93]  6 10 10  9  6  9  1  9
```

```r
table(v)
```

```
## v
##  1  2  3  4  5  6  7  8  9 10
## 10  8  5 10 10 15  8  3 15 16
```

```r
## Functions:
## Numerical calculations for birthday problem:
k <- 40

top <- seq(365,length=k,by=-1) # Creates a vector of 365 to 365-k

bottom <- rep(365,k) # Creates a vector filled with 365 repeated k times

top
```

```
##  [1] 365 364 363 362 361 360 359 358 357 356 355 354 353 352 351 350 349
## [18] 348 347 346 345 344 343 342 341 340 339 338 337 336 335 334 333 332
## [35] 331 330 329 328 327 326
```

```r
bottom
```

```
##  [1] 365 365 365 365 365 365 365 365 365 365 365 365 365 365 365 365 365
## [18] 365 365 365 365 365 365 365 365 365 365 365 365 365 365 365 365 365
## [35] 365 365 365 365 365 365
```

```r
top/bottom
```

```
##  [1] 1.0000000 0.9972603 0.9945205 0.9917808 0.9890411 0.9863014 0.9835616
##  [8] 0.9808219 0.9780822 0.9753425 0.9726027 0.9698630 0.9671233 0.9643836
## [15] 0.9616438 0.9589041 0.9561644 0.9534247 0.9506849 0.9479452 0.9452055
## [22] 0.9424658 0.9397260 0.9369863 0.9342466 0.9315068 0.9287671 0.9260274
## [29] 0.9232877 0.9205479 0.9178082 0.9150685 0.9123288 0.9095890 0.9068493
## [36] 0.9041096 0.9013699 0.8986301 0.8958904 0.8931507
```

```r
prod(top/bottom)  # This is the prob of NO birthday match
```

```
## [1] 0.1087682
```

```r
1 - prod(top/bottom)  # This is the prob of having a birthday match
```

```
## [1] 0.8912318
```

```r
## Let's make a function out of what we just did:

bday <- function(k){ # k is the variable
  top <- seq(365,length=k,by=-1)
  bottom <- rep(365,k)
  return(1-prod(top/bottom))
}

bday(40)
```

```
## [1] 0.8912318
```

```r
#################################################################
## Intro to for loops in R:
#################################################################

s <- 0
for(i in 1:100){
  s <- s+i
}
s
```

```
## [1] 5050
```

```r
## Sometimes you can do the same thing without a loop:
sum(1:100)
```

```
## [1] 5050
```

```r
## You can have more commands in the body of the loop:
s <- 0
for(i in 1:10){
  s <- s+i
  cat("When i = ", i, ", s = ",s, "\n",sep="") # "cat" prints things
}
```

```
## When i = 1, s = 1
## When i = 2, s = 3
## When i = 3, s = 6
## When i = 4, s = 10
## When i = 5, s = 15
## When i = 6, s = 21
```

```
## When i = 7, s = 28
## When i = 8, s = 36
## When i = 9, s = 45
## When i = 10, s = 55
```

```
s <- 0
for(i in 1:10){
  s <- s+i
  cat("When i = ", i, ", s = ",s, "\n",sep="")
  remainder2 <- (i %% 2)
  twos <- i/2
  if(remainder2 == 0){
    cat("I'm getting", rep("really", twos),"tired!\n")
  }
}
```

```
## When i = 1, s = 1
## When i = 2, s = 3
## I'm getting really tired!
## When i = 3, s = 6
## When i = 4, s = 10
## I'm getting really really tired!
## When i = 5, s = 15
## When i = 6, s = 21
## I'm getting really really really tired!
## When i = 7, s = 28
## When i = 8, s = 36
## I'm getting really really really really tired!
## When i = 9, s = 45
## When i = 10, s = 55
## I'm getting really really really really really tired!
```