Get and Load Data

ENTER RAW DATA:

1. In Excel, enter variables in columns with variable names in the first row, each individual's data in rows below that (do not use spaces or special characters).
2. Save as "Comma Separated Values (*.CSV)" file in your local directory/folder.

DATA PROVIDED BY PROFESSOR:

1. Goto the [MTH107 Resources webpage](#).
2. Save "data" link (right-click) to your local directory/folder.

LOAD THE EXTERNAL CSV FILE INTO R:

1. Start script and save it in the same folder with the CSV file.
2. Select the Session, Set Working Directory, To Source File Location menus.
3. Copy resulting **setwd()** code to your script.
4. Use **read.csv()** to load data in *filename.csv* into **dfobj**.

```
dfobj <- read.csv("filename.csv")
```

5. Observe the structure of **dfobj**.

```
str(dfobj)
```

```
> library(NCStats)
> setwd("C:/aaaWork/Web/GitHub/NCMTH107")
> dfcar <- read.csv("93cars.csv")
> str(dfcar)
'data.frame':    93 obs. of  26 variables:
 $ Type    : Factor w/ 6 levels "Compact","Large": 4 3 3 ...
 $ HMPG    : int  31 25 26 26 30 31 28 25 27 25...
 $ Manual  : Factor w/ 2 levels "No","Yes": 2 2 2 2 2 1 1 ...
 $ Weight  : int  2705 3560 3375 3405 3640 2880 3470 ...
 $ Domestic: Factor w/ 2 levels "No","Yes": 1 1 1 1 1 2 2 ...
```

Filter Individuals

Individuals may be selected from the dfobj data.frame and put in the newdf data.frame according to a condition with

```
newdf <- filterD(dfobj,condition)
```

where condition may be as follows

```
var == value                  # equal to
var != value                  # not equal to
var > value                   # greater than
var >= value                  # greater than or equal
var %in% c("val", "val", "val")  # in the list
cond, cond                    # both conditions met
```

with var replaced by a variable name and value replaced by a number or category name (*if* value *is not a number then it must be put in quotes*).

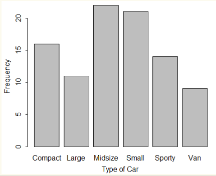
```
> justSporty <- filterD(dfcar,Type=="Sporty")
> noDomestic <- filterD(dfcar,Domestic!="Yes")
> justHMPGgt30 <- filterD(dfcar,HMPG>30)
> Sp_or_Sm <- filterD(dfcar,Type %in% c("Sporty","Small"))
> Spry_n_gt30 <- filterD(dfcar,Type=="Sporty",HMPG>30)
> justWTlteq3000 <- filterD(dfcar,Weight<=3000)
> justNum17 <- dfcar[17,]
> notNum17 <- dfcar[-17,]
```

Univariate EDA

CATEGORICAL – Frequency table, percentage table, and bar chart for the cvar variable.

```
( freq1 <- xtabs(~cvar,data=dfobj) )
percTable(freq1,digits=1)
barplot(freq1,xlab="better cvar label", ylab="Frequency")
```

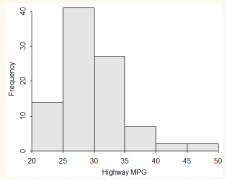
```
> ( freq1 <- xtabs(~Type,data=dfcar) )
 Compact   Large Midsize   Small  Sporty     Van
      16      11      22      21      14       9
> percTable(freq1,digits=1)
 Compact   Large Midsize   Small  Sporty     Van     Sum
    17.2    11.8    23.7    22.6    15.1     9.7   100.1
> barplot(freq1,xlab="Type of Car",ylab="Frequency")
```



QUANTITATIVE – Histogram and summary statistics (mean, median, SD, IQR, etc.) for the qvar variable.

```
hist(~qvar,data=dfobj,xlab="better qvar label")
Summarize(~qvar,data=dfobj,digits=#)
```

```
> hist(~HMPG,data=dfcar,xlab="Highway MPG")
```

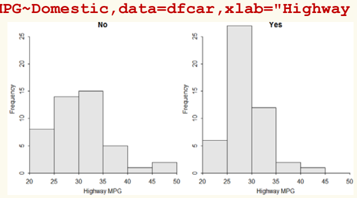



```
> Summarize(~HMPG,data=dfcar,digits=1)
     n    mean      sd     min      Q1  median      Q3     max
  93.0    29.1     5.3    20.0    26.0    28.0    31.0    50.0
```

QUANTITATIVE BY GROUP – Histograms and summary statistics for qvar separated by groups in cvar.

```
hist(qvar~cvar,data=dfobj,xlab="better qvar label")
Summarize(qvar~cvar,data=dfobj,digits=#)
```

```
> hist(HMPG~Domestic,data=dfcar,xlab="Highway MPG")
```




```
> Summarize(HMPG~Domestic,data=dfcar,digits=1)
  Domestic  n mean  sd min Q1 median Q3 max
1       No 45 30.1 6.2  21 25     30 33  50
2      Yes 48 28.1 4.2  20 26     28 30  41
```

Bivariate EDA

CATEGORICAL – Frequency and percentage tables for the cvarRow and cvarCol variables.

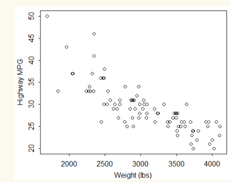
```
( freq2 <- xtabs(~cvarRow+cvarCol, data=dfobj) )
percTable(freq2,digits=1)              # total/table %
percTable(freq2,digits=1,margin=1)     # row %
percTable(freq2,digits=1,margin=2)     # column %
```

```
> ( freq2 <- xtabs(~Domestic+Manual,data=dfcar) )
        Manual
Domestic No Yes
     No   6  39
     Yes 26  22
> percTable(freq2,digits=1)
        Manual
Domestic    No   Yes   Sum
     No    6.5  41.9  48.4
     Yes  28.0  23.7  51.7
     Sum  34.5  65.6 100.1
> percTable(freq2,digits=1,margin=1)
        Manual
Domestic    No   Yes   Sum
     No   13.3  86.7 100.0
     Yes  54.2  45.8 100.0
> percTable(freq2,digits=1,margin=2)
        Manual
Domestic    No   Yes
     No   18.8  63.9
     Yes  81.2  36.1
     Sum 100.0 100.0
```

QUANTITATIVE – Scatterplot and correlation coefficient (r) for the qvarY and qvarX variables.

```
plot(qvarY~qvarX,data=dfobj, pch=19,
     ylab="better yvar label", xlab="better xvar label")
corr(~qvarY+qvarX,data=dfobj,digits=3)
```

```
> plot(HMPG~Weight,data=dfcar,pch=19,ylab="Highway MPG")
       xlab="Weight (lbs)")
```




```
> corr(HMPG~Weight,data=dfcar,digits=3)
  [1] -0.811
```

QUANTITATIVE (ALL PAIRS) – Scatterplot and correlation coefficient (r) for all pairs of quantitative variables.

```
pairs(~qvar1+qvar2+qvar3,data=dfobj, pch=21,bg="gray70")
corr(~qvar1+qvar2+qvar3,data=dfobj,digits=3,
         use="pairwise.complet.obs")
```

```
> pairs(~HMPG+Weight+Cyl,data=dfcar,pch=21,bg="gray70")
> corr(HMPG+Weight+Cyl,data=dfcar,digits=3,
         use="pairwise.complete.obs")
```

Normal Distributions

distrib(val,mean=mnval,sd=sdval,lower.tail=FALSE, type="q")

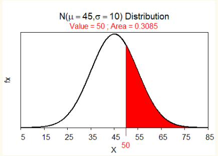
where

- **val** is a value of the quantitative variable (x) or an area (i.e., a percentage, but entered as a proportion).
- **mnval** is the population mean (μ)
- **sdval** is the standard deviation (σ) or error (SE)
- **type="q"** is included for reverse calculations
- **lower.tail=FALSE** is included for "right-of" calculations

For SE use (where **nval**=sample size):

sd=sdval/sqrt(nval)

```
> distrib(50,mean=45,sd=10,lower.tail=FALSE)   #forward-right
```




```
> distrib(50,mean=45,sd=10)                    #forward-left
> distrib(0.05,mean=45,sd=10,type="q")         #rev-left
> distrib(0.2,mean=45,sd=10,type="q",lower.tail=FALSE) #rev-rgt
> distrib(50,mean=45,sd=10/sqrt(30))           #using SE
> distrib(0.95,mean=45,sd=10/sqrt(30),
          type="q",lower.tail=FALSE)           #using SE
```

Linear Regression

The best-fit line between the **qvarResp** response and **qvarExpl** explanatory variables.

(bfl <- lm(qvarResp~qvarExpl,data=dfobj))

A visual of the best-fit line.

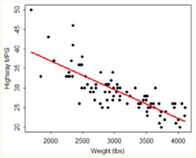
fitPlot(bfl,ylab="better Resp label",xlab="better Expl label")

The r^2 value.

rSquared(bfl)

```
> ( bfl <- lm(HMPG~Weight,data=dfcar) )
  Coefficients:
  (Intercept)       Weight
    51.601365    -0.007327

> fitPlot(bfl,ylab="Highway MPG",xlab="Weight (lbs)")
```




```
> rSquared(bfl)
  [1] 0.6571665
```

Quantitative Hypothesis Tests

ONE SAMPLE Z-TEST AND T-TEST:

z.test(dfobj$qvar,mu=mu0,alt=HA, conf.level=cnfval,sd=sdval)
t.test(dfobj$qvar,mu=mu0,alt=HA, conf.level=cnfval)

- **qvar** is the quantitative response variable in **dfobj**
- **mu0** is the population mean in H_0
- **HA** is replaced with **"two.sided"** for a not equals, **"less"** for a less than, or **"greater"** for a greater than H_A
- **cnfval** is the confidence level as a proportion (e.g., 0.95)
- **sdval** is the known population standard deviation (σ)

```
> z.test(dfcar$HMPG,mu=26,alt="greater",conf.level=0.95,sd=6)
   z= 4.9601, n= 93, Std. Dev= 6.000, Std. Dev of the sample
   mean = 0.622, p-value = 3.523e-07
   alternative hypothesis: true mean is greater than 26
   95 percent confidence interval:
    28.06264      Inf
   sample estimates:
   mean of dfcar$HMPG
             29.08602

> t.test(dfcar$HMPG,mu=26,alt="two.sided",conf.level=0.99)
   t = 5.5818, df = 92, p-value = 2.387e-07
   alternative hypothesis: true mean is not equal to 26
   99 percent confidence interval:
    27.63178 30.54026
   sample estimates:
   mean of x
    29.08602
```

Quantitative Hypothesis Tests

TWO SAMPLE T-TEST:

levenesTest(qvar~cvar,data=dfobj)
**t.test(qvar~cvar,data=dfobj,alt=HA , conf.level=cnfval,
        var.equal=TRUE)**

- **qvar** is the quantitative response variable in **dfobj**
- **cvar** is the categorical variable **that identifies the two groups**
- **mu0** is the population mean in H_0
- **HA** is replaced with **"two.sided"** for a not equals, **"less"** for a less than, or **"greater"** for a greater than H_A
- **cnfval** is the confidence level as a proportion (e.g., 0.95)
- **var.equal=TRUE** if the popn variances are thought to be equal

```
> levenesTest(HMPG~Manual,data=dfcar)
        Df F value   Pr(>F)
  group  1  7.6663 0.006818
        91

> t.test(HMPG~Manual,data=dfcar,alt="less",conf.level=0.99,
         var.equal=TRUE)
   t = -4.2183, df = 91, p-value = 2.904e-05
   alt. hypothesis: true difference in means is less than 0
   99 percent confidence interval:
         -Inf -1.980103
   sample estimates:
    mean in group No mean in group Yes
            26.12500          30.63934
```

Categorical Hypothesis Tests

(TWO SAMPLE) CHI-SQUARE TEST:

Chi-square for two-way frequency table in **obstbl** (with the **cvarResp** categorical response variable in columns and the populations in **cvarPop** as rows).

(obstbl <- xtabs(~cvarPop+cvarResp,data=dfobj))
(chi <- chisq.test(obstbl,correct=FALSE))

Follow-up Analyses:

- Extract expected values.

chi$expected

- Percentages of individuals in each level of the response variable for each population.

percTable(obstbl,margin=1,digits=1)   # row percent table

```
> ( freq2 <- xtabs(~Domestic+Manual,data=dfcar) )
          Manual
  Domestic No Yes
       No   6  39
       Yes 26  22

> ( chi <- chisq.test(freq2,correct=FALSE) )
  Pearson's Chi-squared test with freq2
  X-squared = 17.1588, df = 1, p-value = 3.438e-05

> chi$expected
          Manual
  Domestic       No      Yes
       No  15.48387 29.51613
       Yes 16.51613 31.48387

> percTable(freq2,margin=1,digits=1)
          Manual
  Domestic    No   Yes   Sum
       No   13.3  86.7 100.0
       Yes  54.2  45.8 100.0
```

Categorical Hypothesis Tests

(ONE SAMPLE) GOODNESS-OF-FIT TEST:

Goodness-of-fit for one-way frequency table in **obstbl** and expected values (or ratios) in **exp.p**.

(obstbl <- c(lvl1=##,lvl2=##,lvl3=##))   # if summarized data
(obstbl <- xtabs(~cvarResp,data=dfobj))   # if raw data
(exp.p <- c(lvl1=##,lvl2=##,lvl3=##))
**(gof <- chisq.test(obstbl,p=exp.p,rescale.p=TRUE,
                   correct=FALSE))**

Follow-up Analyses:

- Extract expected values.

gof$expected

- Percentages of individuals in each level of the response variable.

percTable(obstbl,digits=1)