CIND 123: Data Analytics Basic Methods: Assignment-3

Assignment 3 (10%)

Total 100 Marks

[Stephanie Boissonneault]

Instructions

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see http://rmarkdown.rstudio.com.

Use RStudio for this assignment. Complete the assignment by inserting your R code wherever you see the string "#INSERT YOUR ANSWER HERE".

When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

Submit **both** the rmd and generated output files. Failing to submit both files will be subject to mark deduction.

Sample Question and Solution

Use `seq()` to create the vector $(2, 4, 6, \ldots, 20)$.

```
#INSERT YOUR ANSWER HERE.
seq(2,20,by = 2)
```

```
##  [1]  2  4  6  8 10 12 14 16 18 20
```

Question 1 [15 Pts]

a) [5 Pts] First and second midterm grades of some students are given as c(85,76,78,88,90,95,42,31,66) and c(55,66,48,58,80,75,32,22,39). Set R variables `first` and `second` respectively. Then find the least-squares line relating the second midterm to the first midterm.

   Does the assumption of a linear relationship appear to be reasonable in this case? Give reasons to your answer as a comment.

```
first <- c(85,76,78,88,90,95,42,31,66)
second <- c(55,66,48,58,80,75,32,22,39)

lsmodel <- lm(second ~ first)
summary(lsmodel)
```

```
##
## Call:
## lm(formula = second ~ first)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -9.238 -7.747  1.753  4.383 13.318
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  -4.1516    10.9987  -0.377  0.71702
## first         0.7870     0.1461   5.389  0.00102 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.175 on 7 degrees of freedom
## Multiple R-squared:  0.8058, Adjusted R-squared:  0.778
## F-statistic: 29.04 on 1 and 7 DF,  p-value: 0.001021
```

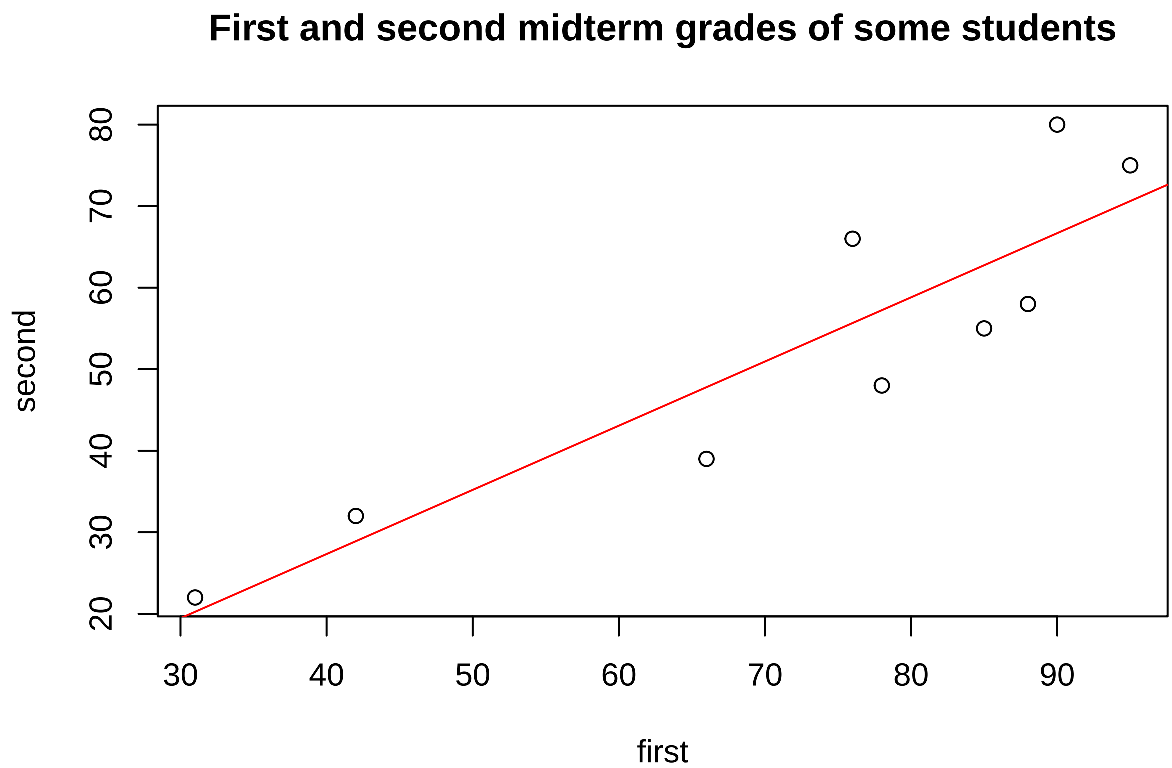
```r
#The assumption of a linear relationship appears to be reasonable because the summary of the line of be
```

b) [5 Pts] Plot the second midterm as a function of the first midterm using a scatterplot and graph the least-square line in red color on the same plot.

```r
print(plot(first, second, main = "First and second midterm grades of some students"))
```

```
## NULL
```

```r
print(abline(lsmodel, col = "red"))
```




```
## NULL
```

c) [5 Pts] Use the regression line to predict the second midterm grades when the first midterm grades are 81 and 23.

```
first.81 <- data.frame(first=c(81))
predict(lsmodel, first.81)
```

```
##        1
## 59.59881
```

```
first.23 <- data.frame(first=c(23))
predict(lsmodel, first.23)
```

```
##        1
## 13.95039
```

Question 2 [45 Pts]

This question makes use of package "plm". Please load Crime dataset as follows:

```r
#install.packages("plm")
library(plm)
```

```
## Warning: package 'plm' was built under R version 4.3.2
```

```r
data(Crime)
```

a) [5 Pts] Display the first 8 rows of 'crime' data and display the names of all the variables, the number of variables, then display a descriptive summary of each variable.

```r
#Display first 8 rows
print(head(Crime, 8))
```

```
##   county year    crmrte   prbarr  prbconv  prbpris avgsen     polpc  density
## 1      1   81 0.0398849 0.289696 0.402062 0.472222   5.61 0.0017868 2.307159
## 2      1   82 0.0383449 0.338111 0.433005 0.506993   5.59 0.0017666 2.330254
## 3      1   83 0.0303048 0.330449 0.525703 0.479705   5.80 0.0018358 2.341801
## 4      1   84 0.0347259 0.362525 0.604706 0.520104   6.89 0.0018859 2.346420
## 5      1   85 0.0365730 0.325395 0.578723 0.497059   6.55 0.0019244 2.364896
## 6      1   86 0.0347524 0.326062 0.512324 0.439863   6.90 0.0018952 2.385681
## 7      1   87 0.0356036 0.298270 0.527596 0.436170   6.71 0.0018279 2.422633
## 8      3   81 0.0163921 0.202899 0.869048 0.465753   8.45 0.0005939 0.976834
##      taxpc  region smsa   pctmin     wcon      wtuc     wtrd     wfir     wser
## 1 25.69763 central   no 20.21870 206.4803  333.6209 182.3330 272.4492 215.7335
## 2 24.87425 central   no 20.21870 212.7542  369.2964 189.5414 300.8788 231.5767
## 3 26.45144 central   no 20.21870 219.7802 1394.8030 196.6395 309.9696 240.1568
## 4 26.84235 central   no 20.21870 223.4238  398.8604 200.5629 350.0863 252.4477
## 5 28.14034 central   no 20.21870 243.7562  358.7830 206.8827 383.0707 261.0861
## 6 29.74098 central   no 20.21870 257.9139  369.5465 218.5165 409.8842 269.6129
## 7 30.99368 central   no 20.21870 281.4259  408.7245 221.2701 453.1722 274.1775
## 8 14.56088 central   no  7.91632 188.7683  292.6422 151.4234 202.4292 191.3742
##     wmfg   wfed   wsta   wloc       mix   pctymle   lcrmrte   lprbarr
## 1 229.12 409.37 236.24 231.47 0.0999179 0.0876968 -3.221757 -1.238923
## 2 240.33 419.70 253.88 236.79 0.1030491 0.0863767 -3.261134 -1.084381
## 3 269.70 438.85 250.36 248.58 0.0806787 0.0850909 -3.496449 -1.107303
## 4 281.74 459.17 261.93 264.38 0.0785035 0.0838333 -3.360270 -1.014662
## 5 298.88 490.43 281.44 288.58 0.0932486 0.0823065 -3.308445 -1.122715
## 6 322.65 478.67 286.91 306.70 0.0973228 0.0800806 -3.359507 -1.120668
## 7 334.54 477.58 292.09 311.91 0.0801688 0.0778710 -3.335309 -1.209756
## 8 210.75 381.72 247.38 213.17 0.0561224 0.0870046 -4.110956 -1.595047
##     lprbconv   lprbpris  lavgsen    lpolpc   ldensity    lwcon    lwtuc
## 1 -0.9111490 -0.7503061 1.724551 -6.327340  0.8360171 5.330205 5.810005
## 2 -0.8370060 -0.6792581 1.720979 -6.338704  0.8459773 5.360137 5.911600
## 3 -0.6430188 -0.7345839 1.757858 -6.300291  0.8509204 5.392628 7.240509
## 4 -0.5030129 -0.6537265 1.930071 -6.273361  0.8528909 5.409070 5.988612
## 5 -0.5469313 -0.6990466 1.879465 -6.253162  0.8607340 5.496169 5.882718
## 6 -0.6687981 -0.8212920 1.931521 -6.268420  0.8694848 5.552626 5.912277
## 7 -0.6394244 -0.8297232 1.903599 -6.304609  0.8848549 5.639869 6.013041
## 8 -0.1403569 -0.7640998 2.134166 -7.428766 -0.0234386 5.240520 5.678950
##      lwtrd    lwfir    lwser    lwmfg    lwfed    lwsta    lwloc  lpctymle
## 1 5.205835 5.607452 5.374044 5.434246 6.014619 5.464848 5.444450 -2.433870
## 2 5.244607 5.706707 5.444911 5.482013 6.039540 5.536862 5.467174 -2.449038
```

```
## 3 5.281372 5.736475 5.481292 5.597310 6.084157 5.522900 5.515765 -2.464036
## 4 5.301128 5.858180 5.531204 5.640985 6.129421 5.568077 5.577387 -2.478925
## 5 5.332152 5.948220 5.564850 5.700042 6.195282 5.639919 5.664972 -2.497306
## 6 5.386862 6.015875 5.596987 5.776568 6.171011 5.659169 5.725870 -2.524721
## 7 5.399384 6.116272 5.613776 5.812757 6.168732 5.677062 5.742715 -2.552702
## 8 5.020080 5.310390 5.254230 5.350673 5.944687 5.510926 5.362090 -2.441794
##    lpctmin   ltaxpc      lmix
## 1 3.006608 3.246399 -2.303407
## 2 3.006608 3.213833 -2.272549
## 3 3.006608 3.275311 -2.517281
## 4 3.006608 3.289981 -2.544612
## 5 3.006608 3.337204 -2.372487
## 6 3.006608 3.392526 -2.329722
## 7 3.006608 3.433783 -2.523621
## 8 2.068926 2.678338 -2.880219
```

```r
#Display all variable names
print(ls(Crime))
```

```
##  [1] "avgsen"   "county"   "crmrte"   "density"  "lavgsen"  "lcrmrte"
##  [7] "ldensity" "lmix"     "lpctmin"  "lpctymle" "lpolpc"   "lprbarr"
## [13] "lprbconv" "lprbpris" "ltaxpc"   "lwcon"    "lwfed"    "lwfir"
## [19] "lwloc"    "lwmfg"    "lwser"    "lwsta"    "lwtrd"    "lwtuc"
## [25] "mix"      "pctmin"   "pctymle"  "polpc"    "prbarr"   "prbconv"
## [31] "prbpris"  "region"   "smsa"     "taxpc"    "wcon"     "wfed"
## [37] "wfir"     "wloc"     "wmfg"     "wser"     "wsta"     "wtrd"
## [43] "wtuc"     "year"
```

```r
#Display number of variables
print(length(ls(Crime)))
```

```
## [1] 44
```

```r
#Display each variable's descriptive summary
print(summary(Crime))
```

```
##      county           year        crmrte              prbarr
##  Min.   :  1.0   Min.   :81   Min.   :0.001812   Min.   :0.05882
##  1st Qu.: 51.0   1st Qu.:82   1st Qu.:0.018352   1st Qu.:0.21790
##  Median :103.0   Median :84   Median :0.028441   Median :0.27824
##  Mean   :100.6   Mean   :84   Mean   :0.031588   Mean   :0.30737
##  3rd Qu.:151.0   3rd Qu.:86   3rd Qu.:0.038406   3rd Qu.:0.35252
##  Max.   :197.0   Max.   :87   Max.   :0.163835   Max.   :2.75000
##     prbconv            prbpris           avgsen           polpc
##  Min.   : 0.06838   Min.   :0.1489   Min.   : 4.220   Min.   :0.0004585
##  1st Qu.: 0.34769   1st Qu.:0.3744   1st Qu.: 7.160   1st Qu.:0.0011913
##  Median : 0.47437   Median :0.4286   Median : 8.495   Median :0.0014506
##  Mean   : 0.68862   Mean   :0.4255   Mean   : 8.955   Mean   :0.0019168
##  3rd Qu.: 0.63560   3rd Qu.:0.4832   3rd Qu.:10.197   3rd Qu.:0.0018033
##  Max.   :37.00000   Max.   :0.6786   Max.   :25.830   Max.   :0.0355781
##     density           taxpc            region     smsa         pctmin
##  Min.   :0.1977   Min.   : 14.30   other  :245   no :574   Min.   : 1.284
```

```
##  1st Qu.:0.5329   1st Qu.: 23.43   west   :147   yes: 56   1st Qu.:10.005
##  Median :0.9526   Median : 27.79   central:238             Median :24.852
##  Mean   :1.3861   Mean   : 30.24                           Mean   :25.713
##  3rd Qu.:1.5078   3rd Qu.: 33.27                           3rd Qu.:38.223
##  Max.   :8.8277   Max.   :119.76                           Max.   :64.348
##       wcon              wtuc              wtrd              wfir
##  Min.   :  65.62   Min.   :  28.86   Min.   :  16.87   Min.   :  3.516
##  1st Qu.: 201.66   1st Qu.: 317.60   1st Qu.: 168.05   1st Qu.:235.705
##  Median : 236.46   Median : 358.20   Median : 185.48   Median :264.423
##  Mean   : 245.67   Mean   : 406.10   Mean   : 192.82   Mean   :272.059
##  3rd Qu.: 269.69   3rd Qu.: 411.02   3rd Qu.: 204.82   3rd Qu.:302.440
##  Max.   :2324.60   Max.   :3041.96   Max.   :2242.75   Max.   :509.466
##       wser              wmfg            wfed            wsta
##  Min.   :   1.844   Min.   :101.8   Min.   :255.4   Min.   :173.0
##  1st Qu.: 191.319   1st Qu.:234.0   1st Qu.:361.5   1st Qu.:258.2
##  Median : 216.475   Median :271.6   Median :404.0   Median :289.4
##  Mean   : 224.671   Mean   :285.2   Mean   :403.9   Mean   :296.9
##  3rd Qu.: 247.155   3rd Qu.:320.0   3rd Qu.:444.6   3rd Qu.:331.5
##  Max.   :2177.068   Max.   :646.9   Max.   :598.0   Max.   :548.0
##       wloc             mix              pctymle           lcrmrte
##  Min.   :163.6   Min.   :0.002457   Min.   :0.06216   Min.   :-6.314
##  1st Qu.:226.8   1st Qu.:0.075324   1st Qu.:0.07859   1st Qu.:-3.998
##  Median :253.1   Median :0.102089   Median :0.08316   Median :-3.560
##  Mean   :258.0   Mean   :0.139396   Mean   :0.08897   Mean   :-3.609
##  3rd Qu.:289.3   3rd Qu.:0.149009   3rd Qu.:0.08919   3rd Qu.:-3.260
##  Max.   :388.1   Max.   :4.000000   Max.   :0.27436   Max.   :-1.809
##     lprbarr          lprbconv          lprbpris          lavgsen
##  Min.   :-2.833   Min.   :-2.6827   Min.   :-1.9042   Min.   :1.440
##  1st Qu.:-1.524   1st Qu.:-1.0564   1st Qu.:-0.9824   1st Qu.:1.969
##  Median :-1.279   Median :-0.7458   Median :-0.8473   Median :2.139
##  Mean   :-1.274   Mean   :-0.6929   Mean   :-0.8786   Mean   :2.153
##  3rd Qu.:-1.043   3rd Qu.:-0.4532   3rd Qu.:-0.7273   3rd Qu.:2.322
##  Max.   : 1.012   Max.   : 3.6109   Max.   :-0.3878   Max.   :3.252
##      lpolpc          ldensity            lwcon           lwtuc
##  Min.   :-7.688   Min.   :-1.62091   Min.   :4.184   Min.   :3.362
##  1st Qu.:-6.733   1st Qu.:-0.62934   1st Qu.:5.307   1st Qu.:5.761
##  Median :-6.536   Median :-0.04857   Median :5.466   Median :5.881
##  Mean   :-6.491   Mean   :-0.01593   Mean   :5.463   Mean   :5.916
##  3rd Qu.:-6.318   3rd Qu.: 0.41066   3rd Qu.:5.597   3rd Qu.:6.019
##  Max.   :-3.336   Max.   : 2.17789   Max.   :7.751   Max.   :8.020
##      lwtrd           lwfir           lwser            lwmfg
##  Min.   :2.826   Min.   :1.257   Min.   :0.6118   Min.   :4.623
##  1st Qu.:5.124   1st Qu.:5.463   1st Qu.:5.2539   1st Qu.:5.455
##  Median :5.223   Median :5.578   Median :5.3775   Median :5.604
##  Mean   :5.232   Mean   :5.579   Mean   :5.3646   Mean   :5.615
##  3rd Qu.:5.322   3rd Qu.:5.712   3rd Qu.:5.5100   3rd Qu.:5.768
##  Max.   :7.715   Max.   :6.233   Max.   :7.6857   Max.   :6.472
##      lwfed           lwsta           lwloc          lpctymle
##  Min.   :5.543   Min.   :5.153   Min.   :5.097   Min.   :-2.778
##  1st Qu.:5.890   1st Qu.:5.554   1st Qu.:5.424   1st Qu.:-2.543
##  Median :6.001   Median :5.668   Median :5.534   Median :-2.487
##  Mean   :5.989   Mean   :5.678   Mean   :5.540   Mean   :-2.443
##  3rd Qu.:6.097   3rd Qu.:5.804   3rd Qu.:5.667   3rd Qu.:-2.417
##  Max.   :6.394   Max.   :6.306   Max.   :5.961   Max.   :-1.293
```

```
##     lpctmin           ltaxpc           lmix
##  Min.   :0.2497   Min.   :2.660   Min.   :-6.009
##  1st Qu.:2.3030   1st Qu.:3.154   1st Qu.:-2.586
##  Median :3.2127   Median :3.325   Median :-2.282
##  Mean   :2.9134   Mean   :3.356   Mean   :-2.234
##  3rd Qu.:3.6434   3rd Qu.:3.505   3rd Qu.:-1.904
##  Max.   :4.1643   Max.   :4.786   Max.   : 1.386
```

b) [5 Pts] Calculate the mean,variance and standard deviation of probability of arrest (prbarr) by omitting the missing values, if any.

```r
#mean
prbarr_avg <- mean(Crime$prbarr, na.rm = TRUE)
prbarr_avg
```

```
## [1] 0.3073682
```

```r
#variance
prbarr_var <- var(Crime$prbarr, na.rm = TRUE)
prbarr_var
```

```
## [1] 0.02931104
```

```r
#standard deviation
prbarr_sd <- sqrt(prbarr_var)
prbarr_sd
```

```
## [1] 0.1712047
```

c) [5 Pts] Use `lpolpc` (log-police per capita) and `smsa` variables to build a linear regression model to predict probability of arrest (prbarr). And, compare with another linear regression model that uses `polpc` (police per capita) and `smsa`.

[5 Pts] How can you draw a conclusion from the results? (Note: Full marks requires comment on the predictors)

```r
#Multiple linear regression
model1 <- lm(prbarr ~ lpolpc + smsa, data = Crime)
summary(model1)
```

```
##
## Call:
## lm(formula = prbarr ~ lpolpc + smsa, data = Crime)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.46050 -0.07973 -0.01784  0.05390  2.24094
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.88964    0.08152  10.913  < 2e-16 ***
```

```
## lpolpc       0.08784    0.01246   7.048 4.80e-12 ***
## smsayes     -0.13638    0.02305  -5.918 5.38e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1623 on 627 degrees of freedom
## Multiple R-squared:  0.104,  Adjusted R-squared:  0.1012
## F-statistic:  36.4 on 2 and 627 DF,  p-value: 1.109e-15
```

```
model2 <- lm(prbarr ~ polpc + smsa, data = Crime)
summary(model2)
```

```
##
## Call:
## lm(formula = prbarr ~ polpc + smsa, data = Crime)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.72651 -0.07840 -0.01759  0.04955  2.22692
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.28213    0.00807  34.958  < 2e-16 ***
## polpc       18.34603    2.34684   7.817 2.29e-14 ***
## smsayes     -0.11163    0.02254  -4.953 9.40e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.161 on 627 degrees of freedom
## Multiple R-squared:  0.1189, Adjusted R-squared:  0.1161
## F-statistic: 42.31 on 2 and 627 DF,  p-value: < 2.2e-16
```

```
#The p value of the F statistic in model1 and model2 are both highly significant. Model1 residuals have

#Looking at the Coefficients from Model1, we can conclude that there is a highly significant (Pr(>|t|**

#Looking at the Coefficients from Model2, we can conclude that there is a highly significant (Pr(>|t|**
```

d) [5 Pts] Based on the output of your model, write the equations using the intercept and factors of `smsa` when `polpc` is set to 0.0015. and compare the result with `predict()` function.
Hint: Explore `predict()` function

```
#Model 2 equation when smsa is no
y.smsano = 0.28213 + 18.34603*(0.0015)
y.smsano
```

```
## [1] 0.309649
```

```
#Model2 equation when smsa is yes
y.smsayes =  0.28213 + 18.34603*(0.0015) - 0.11163
y.smsayes
```

```
## [1] 0.198019
```

```r
#Temporary dataframe to set polpc to 0.0015
polpc.smsa.df <- data.frame(polpc = c(0.0015), smsa = c('no','yes'))
predict(model2, polpc.smsa.df)
```

```
##         1         2
## 0.3096441 0.1980168
```

```r
#The results obtained from using the predict function are exactly the same up to 5 decimal points.
```

e) [5 Pts] Find Pearson correlation between probability of prison sentence `prbpris` and tax per capita `taxpc`; and also Pearson correlation between probability of conviction `prbconv` and probability of arrest `prbarr`.

   [5 Pts] What conclusions can you draw? Write your reasons as comments.

```r
cor.test(Crime$prbpris, Crime$taxpc)
```

```
##
##  Pearson's product-moment correlation
##
## data:  Crime$prbpris and Crime$taxpc
## t = -2.8261, df = 628, p-value = 0.004862
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.18852675 -0.03424894
## sample estimates:
##        cor
## -0.1120631
```

```r
#We can conclude that there is a very low negative linear correlation between prison sentence (prbpris)
```

```r
cor.test(Crime$prbconv, Crime$prbarr)
```

```
##
##  Pearson's product-moment correlation
##
## data:  Crime$prbconv and Crime$prbarr
## t = 0.89192, df = 628, p-value = 0.3728
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  -0.04266359  0.11336788
## sample estimates:
##       cor
## 0.0355689
```

```r
#We can conclude that there is a very low positive correlation linear relationship between the probabil
```

f) [5 Pts] Display the correlation matrix of the variables: prbconv, prbpris, avgsen, polpc.

   [5 Pts] Write what conclusion you can draw, as comments.

```r
#install.packages("corrplot")
library(corrplot)
```

```
## Warning: package 'corrplot' was built under R version 4.3.2
```

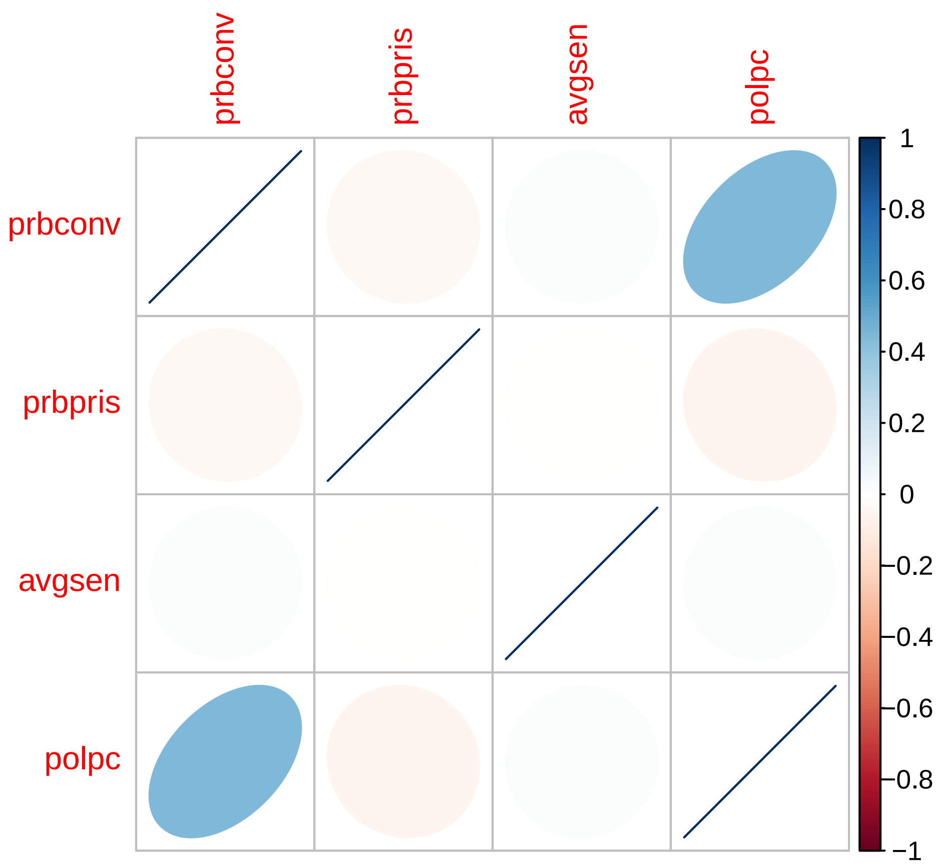
```
## corrplot 0.92 loaded
```

```r
table_cor<- cor(Crime[,5:8])
table_cor
```

```
##             prbconv      prbpris       avgsen       polpc
## prbconv  1.00000000 -0.037340175  0.015304708  0.44963500
## prbpris -0.03734017  1.000000000 -0.004299394 -0.05745238
## avgsen   0.01530471 -0.004299394  1.000000000  0.01712970
## polpc    0.44963500 -0.057452385  0.017129699  1.00000000
```

```r
#We can conclude that there is a moderate positive correlation coefficient between prbconv and polpc (0

#We can also conclude that there is very little  negative linear relationship between prbconv and prbpr

#We can also conclude that there is a very low positive correlation between prbconv and avgsen (0.015)
```

```r
#Further visualizing pearson correlations
corrplot(table_cor, method = "ellipse")
```



Question 3 [15 Pts]

This question makes use of package "ISwR". Please load `airquality` dataset as following:

```r
#install.packages("ISwR")
library(ISwR)
```

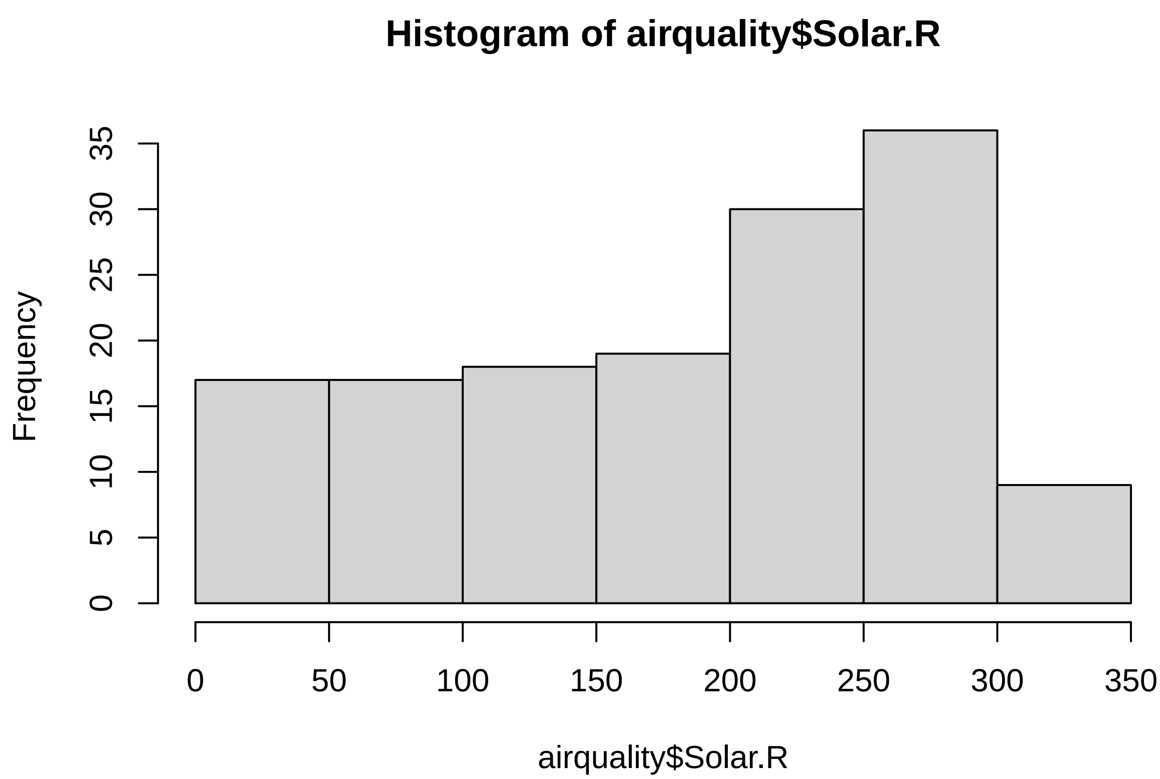
```
## Warning: package 'ISwR' was built under R version 4.3.2
```

```r
data(airquality)
str(airquality)
```

```
## 'data.frame':    153 obs. of  6 variables:
##  $ Ozone  : int  41 36 12 18 NA 28 23 19 8 NA ...
##  $ Solar.R: int  190 118 149 313 NA NA 299 99 19 194 ...
##  $ Wind   : num  7.4 8 12.6 11.5 14.3 14.9 8.6 13.8 20.1 8.6 ...
##  $ Temp   : int  67 72 74 62 56 66 65 59 61 69 ...
##  $ Month  : int  5 5 5 5 5 5 5 5 5 5 ...
##  $ Day    : int  1 2 3 4 5 6 7 8 9 10 ...
```

a) [5 Pts] Plot a histogram to assess the normality of the `Solar.R` variable, then explain why it does not appear normally distributed.

```r
print(hist(airquality$Solar.R))
```



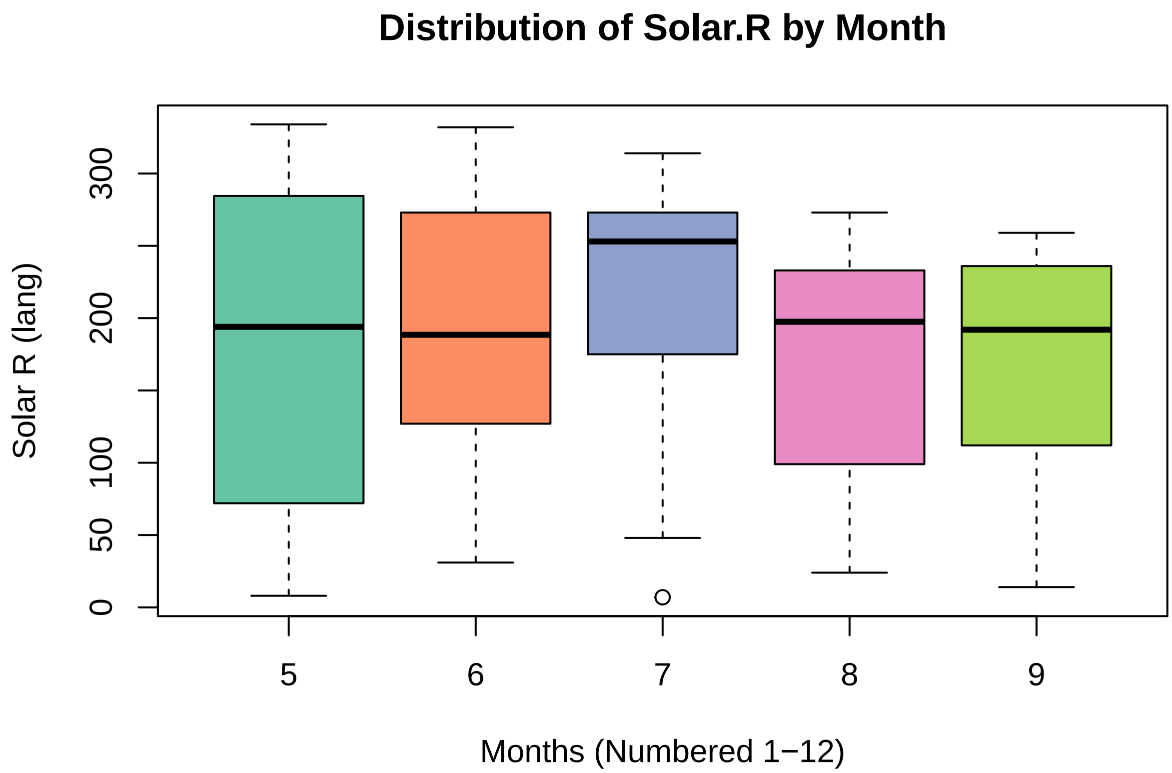
```
## $breaks
## [1]   0  50 100 150 200 250 300 350
##
## $counts
## [1] 17 17 18 19 30 36  9
##
## $density
## [1] 0.002328767 0.002328767 0.002465753 0.002602740 0.004109589 0.004931507
## [7] 0.001232877
##
## $mids
## [1]  25  75 125 175 225 275 325
##
## $xname
## [1] "airquality$Solar.R"
##
## $equidist
## [1] TRUE
##
## attr(,"class")
## [1] "histogram"
```

```r
#This variable does not appear normally distributed because the histogram is not a bell shaped curve (t
```

b) [5 Pts] Create a boxplot that shows the distribution of `Solar.R` in each month. Use different colors for each month.

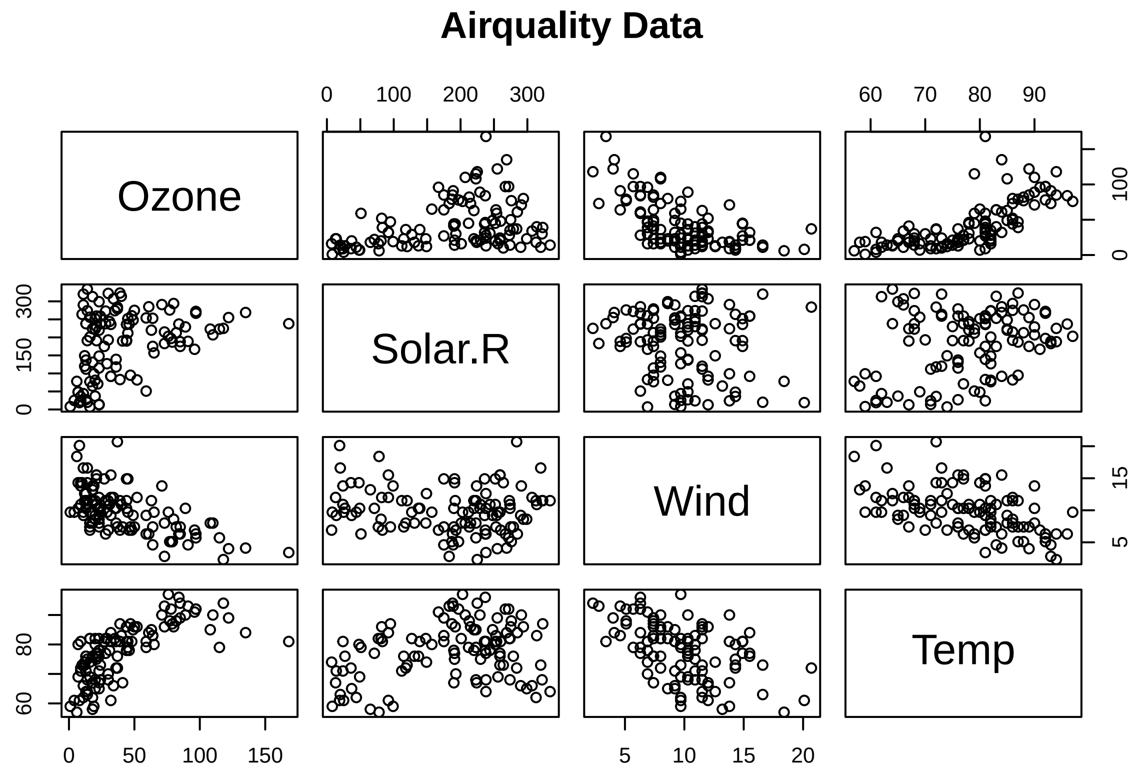
```r
#Colour vector preparation
library (RColorBrewer)

boxplot(Solar.R ~ Month, data = airquality, main = "Distribution of Solar.R by Month", xlab = "Months (
```

```
## Warning in brewer.pal(12, name = "Set2"): n too large, allowed maximum for palette Set2 is 8
## Returning the palette you asked for with that many colors
```



c) [5 Pts] Create a matrix of scatterplots of all the numeric variables in the `airquality` dataset (i.e. Ozone, Solar.R, Wind and Temp.) (Hint: investigate pairs() function)

```
#Matrix only comparing: Ozone, Solar.R, Wind and Temp
print(pairs(~ Ozone + Solar.R + Wind + Temp, data = airquality, main = "Airquality Data", na.action = na
```




```
## NULL
```

Question 4 [25 Pts]

Many times in data analysis, we need a method that relies on repeated random sampling to obtain numerical results. The underlying concept is to use randomness to solve problems. In fact, this is a mathematical technique, which is used to estimate the possible outcomes of an uncertain event and is called the *Monte Carlo Method*.

Consider that We roll a die 10 times and we want to know the probability of getting more than 3 times of even numbers. This is a problem for the Binomial distribution, but suppose we don't know anything about Binomial distribution. We can easily solve this problem with a Monte Carlo Simulation.

a) [5 Pts] The Monte Carlo Method uses random numbers to simulate some process. Here the process is rolling a die 10 times. Assume the die is fair. What is the probability of success or getting an even number in rolling the die once?

```r
#install.packages("gtools")
library(gtools)
```

```
## Warning: package 'gtools' was built under R version 4.3.2
```

```r
one.dice <- c(1, 2, 3, 4, 5, 6)
perm <- permutations(length(one.dice), 1, one.dice,
repeats.allowed =TRUE)
perm
```

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

```r
#Probability of success of rolling an even number when rolling the die once is 3/6 or 0.5
```

b) [10 Pts] Define a function named `one.trial`, that simulates a single round of rolling a die 10 times and returns true if the number of even numbers is > 3.

```r
#INSERT YOUR ANSWER HERE.
one.trial <- function(){

  die <- c()
  num_even <- 0

  #Roll the die and store rolls in a vector called "die"
  for (roll in 1:10){
      die <- append(die, sample(1:6, size = 1, replace = TRUE))
  }
  #print(die)

  #Count number of even numbers in the vector "die"
      for (i in die) {
        if (i == 2) {
          num_even <- num_even + 1
        } else if (i == 4){
          num_even <- num_even + 1
        } else if (i == 6){
          num_even <- num_even + 1
        } else {
          num_even <- num_even + 0
        }
      }
  #print(num_even)

  #Determine whether count of even numbers is over 3
  if (num_even > 3) {
    return(TRUE)
  } else{
    return(FALSE)
  }

  }
```

```r
one.trial()
```

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

c) [5 pts] Repeat the function `one.trial` for `N = 100,000` times and sum up the outcomes and store the result in a variable named `desired.output`. Compute the probability of getting more than 3 times of even numbers by using relative frequency.

```r
#Returns the number one.trial() that is equal to TRUE (>3 even numbers)
set.seed(10)
desired.output <- sum(replicate(n = 100000, expr = one.trial()))
desired.output
```

```
## [1] 82924
```

```r
my.probability <- desired.output/100000
my.probability
```

```
## [1] 0.82924
```

d) [5 pts] Use the Binomial formula you learned before to calculate such probability and Compare it with the probability value obtained in part (c).

```r
set.seed(10)
pbinom(q = 3, size = 10, prob = 1/2)
```

```
## [1] 0.171875
```

Congratulations! you have completed the first run of the Monte Carlo simulation.

If there is further interest, put all the above logic in a function, and call it 50 times at least, and store the results in a vector called Prob then take the mean of Prob vector to be more accurate.

** End of Assignment **