Import dataset from the following link:
https://archive.ics.uci.edu/ml/machine-learning-databases/00360/

Perform the below written operations:

a. **Read the file in Zip format and get it into R**

```
#Read the file in Zip format and get it into R.
#Answer1
forecasturl = paste('https://archive.ics.uci.edu/ml/machine-learning-databases/00360/',
            'AirQualityUCI.zip', sep='')
# create a temporary directory
td = tempdir()
# create the placeholder file
tf = tempfile(tmpdir=td, fileext=".zip")
# download into the placeholder file
download.file(forecasturl, tf)
# get the name of the first file in the zip archive
fname = unzip(tf, list=TRUE)$Name[1]
fname
# unzip the file to the temporary directory
unzip(tf, files=fname, exdir=td, overwrite=TRUE)
# fpath is the full path to the extracted file
fpath = file.path(td, fname)
fpath
d = read.csv(fpath,sep = ";")
View(d)
```

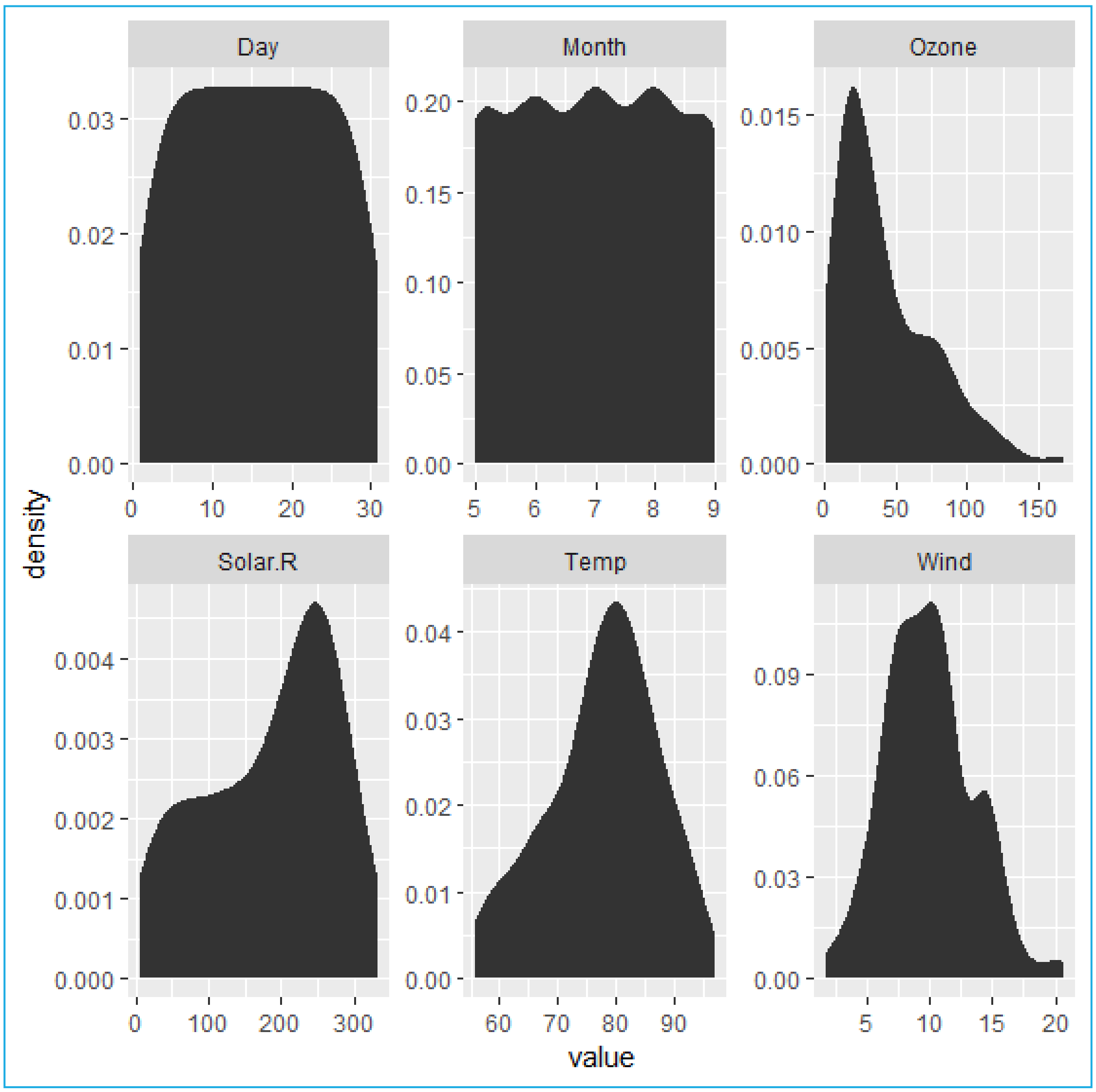
```
> #Read the file in zip format and get it into R.
> #Answer1
> forecasturl = paste('https://archive.ics.uci.edu/ml/machine-learning-databases/00360/',
+                     'AirQualityUCI.zip', sep='')
> # create a temporary directory
> td = tempdir()
> # create the placeholder file
> tf = tempfile(tmpdir=td, fileext=".zip")
> # download into the placeholder file
> download.file(forecasturl, tf)
trying URL 'https://archive.ics.uci.edu/ml/machine-learning-databases/00360/AirQualityUCI.zip'
Content type 'application/zip' length 1543989 bytes (1.5 MB)
downloaded 1.5 MB

> # get the name of the first file in the zip archive
> fname = unzip(tf, list=TRUE)$Name[1]
> fname
[1] "AirQualityUCI.csv"
> # unzip the file to the temporary directory
> unzip(tf, files=fname, exdir=td, overwrite=TRUE)
> # fpath is the full path to the extracted file
> fpath = file.path(td, fname)
> fpath
[1] "C:\\Users\\VINEET~1\\AppData\\Local\\Temp\\RtmpwVxMFb/AirQualityUCI.csv"
> d = read.csv(fpath,sep = ";")
> View(d)
>
```

	Date	Time	CO.GT.	PT08.S1.CO.	NMHC.GT.	C6H6.GT.	PT08.S2.NMHC.	NOx.GT.	PT08.S3.NOx.	NO2.GT.	PT08.S4.NO2.	PT08.S5.O3.	T	RH	AH	X	X.1
1	10/03/2004	18.00.00	2,6	1360	150	11,9	1046	166	1056	113	1692	1268	13,6	48,9	0,7578	NA	NA
2	10/03/2004	19.00.00	2	1292	112	9,4	955	103	1174	92	1559	972	13,3	47,7	0,7255	NA	NA
3	10/03/2004	20.00.00	2,2	1402	88	9,0	939	131	1140	114	1555	1074	11,9	54,0	0,7502	NA	NA
4	10/03/2004	21.00.00	2,2	1376	80	9,2	948	172	1092	122	1584	1203	11,0	60,0	0,7867	NA	NA
5	10/03/2004	22.00.00	1,6	1272	51	6,5	836	131	1205	116	1490	1110	11,2	59,6	0,7888	NA	NA
6	10/03/2004	23.00.00	1,2	1197	38	4,7	750	89	1337	96	1393	949	11,2	59,2	0,7848	NA	NA
7	11/03/2004	00.00.00	1,2	1185	31	3,6	690	62	1462	77	1333	733	11,3	56,8	0,7603	NA	NA
8	11/03/2004	01.00.00	1	1136	31	3,3	672	62	1453	76	1333	730	10,7	60,0	0,7702	NA	NA
9	11/03/2004	02.00.00	0,9	1094	24	2,3	609	45	1579	60	1276	620	10,7	59,7	0,7648	NA	NA
10	11/03/2004	03.00.00	0,6	1010	19	1,7	561	-200	1705	-200	1235	501	10,3	60,2	0,7517	NA	NA
11	11/03/2004	04.00.00	-200	1011	14	1,3	527	21	1818	34	1197	445	10,1	60,5	0,7465	NA	NA
12	11/03/2004	05.00.00	0,7	1066	8	1,1	512	16	1918	28	1182	422	11,0	56,2	0,7366	NA	NA
13	11/03/2004	06.00.00	0,7	1052	16	1,6	553	34	1738	48	1221	472	10,5	58,1	0,7353	NA	NA
14	11/03/2004	07.00.00	1,1	1144	29	3,2	667	98	1490	82	1339	730	10,2	59,6	0,7417	NA	NA

b. Create Univariate for all the columns.

```
#we can do univariate analysis by the following command too
summary(airquality)
describe(airquality)

#or by visually
library(purrr)
library(tidyr)
library(ggplot2)

airquality%>%
  keep(is.numeric)%>%
  gather()%>%
  ggplot(aes(value)) +
  facet_wrap(~ key,scales = "free") +
  stat_density()
```

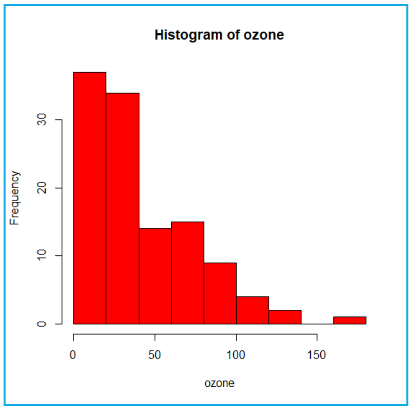
```
> #we can do univariate analysis by the following command too
> summary(airquality)
     Ozone           Solar.R           Wind             Temp           Month            Day      
 Min.   :  1.00   Min.   :  7.0   Min.   : 1.700   Min.   :56.00   Min.   :5.000   Min.   : 1.0  
 1st Qu.: 18.00   1st Qu.:115.8   1st Qu.: 7.400   1st Qu.:72.00   1st Qu.:6.000   1st Qu.: 8.0  
 Median : 31.50   Median :205.0   Median : 9.700   Median :79.00   Median :7.000   Median :16.0  
 Mean   : 42.13   Mean   :185.9   Mean   : 9.958   Mean   :77.88   Mean   :6.993   Mean   :15.8  
 3rd Qu.: 63.25   3rd Qu.:258.8   3rd Qu.:11.500   3rd Qu.:85.00   3rd Qu.:8.000   3rd Qu.:23.0  
 Max.   :168.00   Max.   :334.0   Max.   :20.700   Max.   :97.00   Max.   :9.000   Max.   :31.0  
 NA's   :37       NA's   :7                                                                       
> describe(airquality)
        vars   n   mean    sd median trimmed   mad  min   max range  skew kurtosis   se
Ozone      1 116  42.13 32.99   31.5   37.80 25.95  1.0 168.0   167  1.21     1.11 3.06
Solar.R    2 146 185.93 90.06  205.0  190.34 98.59  7.0 334.0   327 -0.42    -1.00 7.45
Wind       3 153   9.96  3.52    9.7    9.87  3.41  1.7  20.7    19  0.34     0.03 0.28
Temp       4 153  77.88  9.47   79.0   78.28  8.90 56.0  97.0    41 -0.37    -0.46 0.77
Month      5 153   6.99  1.42    7.0    6.99  1.48  5.0   9.0     4  0.00    -1.32 0.11
Day        6 153  15.80  8.86   16.0   15.80 11.86  1.0  31.0    30  0.00    -1.22 0.72
> 
```

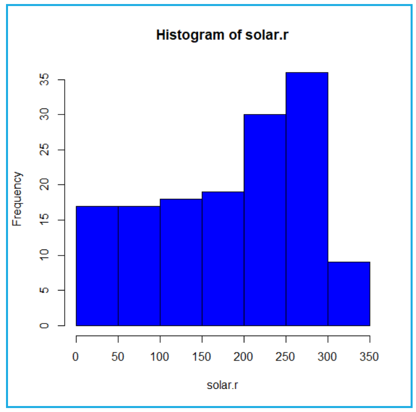


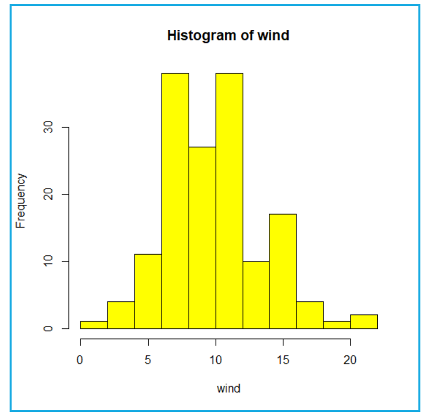
#or we can plot univariate individually for each variable

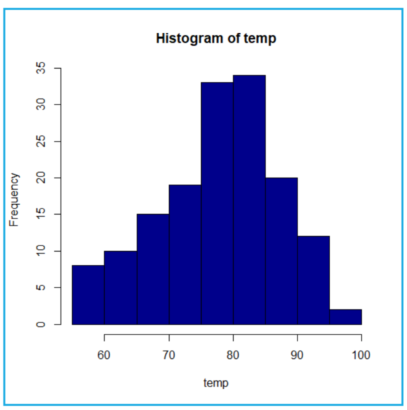
#hence plotting histogram

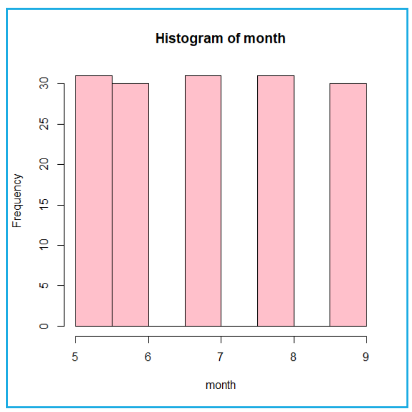
hist(airquality$Ozone ,xlab = "ozone", ylab = "Frequency",main="Histogram of ozone",col="red")
hist(airquality$Solar.R ,xlab = "solar.r", ylab = "Frequency",main="Histogram of solar.r",col="blue")
hist(airquality$Wind ,xlab = "wind", ylab = "Frequency",main="Histogram of wind",col="yellow")
hist(airquality$Temp ,xlab = "temp", ylab = "Frequency",main="Histogram of temp",col="darkblue")
hist(airquality$Month ,xlab = "month", ylab = "Frequency",main="Histogram of month",col="pink")
hist(airquality$Day ,xlab = "day", ylab = "Frequency",main="Histogram of day",col="purple")

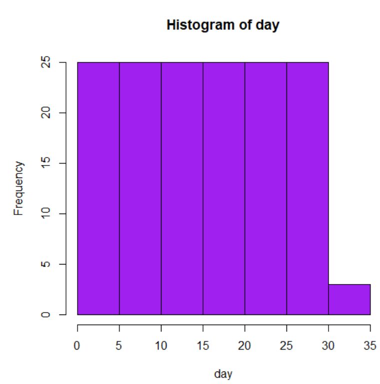












c. Check for missing values in all columns.

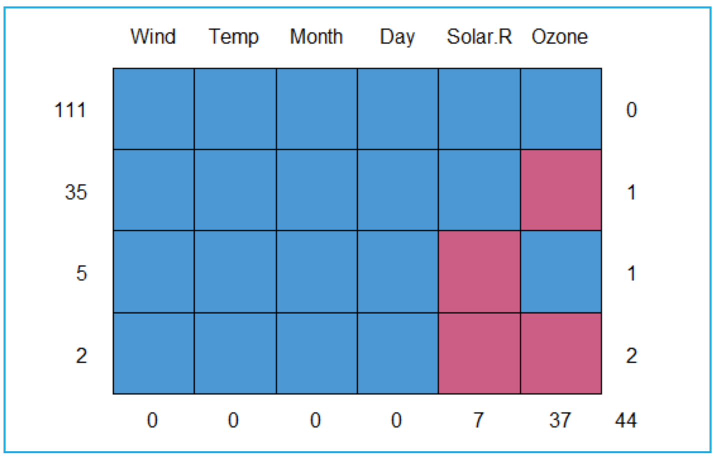
```
     Ozone           Solar.R           Wind             Temp           Month            Day      
 Min.   :  1.00   Min.   :  7.0   Min.   : 1.700   Min.   :56.00   Min.   :5.000   Min.   : 1.0  
 1st Qu.: 18.00   1st Qu.:115.8   1st Qu.: 7.400   1st Qu.:72.00   1st Qu.:6.000   1st Qu.: 8.0  
 Median : 31.50   Median :205.0   Median : 9.700   Median :79.00   Median :7.000   Median :16.0  
 Mean   : 42.13   Mean   :185.9   Mean   : 9.958   Mean   :77.88   Mean   :6.993   Mean   :15.8  
 3rd Qu.: 63.25   3rd Qu.:258.8   3rd Qu.:11.500   3rd Qu.:85.00   3rd Qu.:8.000   3rd Qu.:23.0  
 Max.   :168.00   Max.   :334.0   Max.   :20.700   Max.   :97.00   Max.   :9.000   Max.   :31.0  
 NA's   :37       NA's   :7                                                                       
>
```

#thus ozone and solar.r has missing values

d. Impute the missing values using appropriate methods

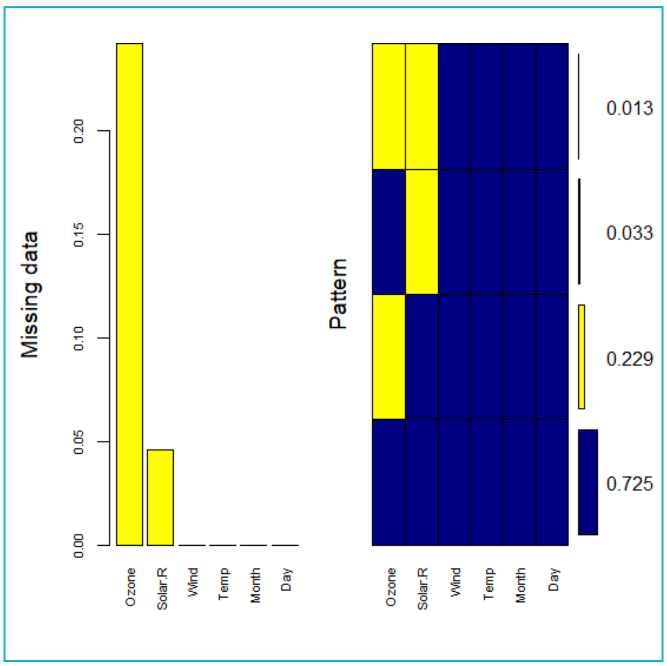
```
#first lets see the structure of airquality
str(airquality)
#Load Mice Library
library(mice)
md.pattern(airquality)
```

```
> md.pattern(airquality)
    Wind Temp Month Day Solar.R Ozone
111    1    1     1   1       1     1  0
35     1    1     1   1       1     0  1
5      1    1     1   1       0     1  1
2      1    1     1   1       0     0  2
       0    0     0   0       7    37 44
> 
```



```
#visualizing
library(VIM)
mice_plot <- aggr(airquality, col=c('navyblue','yellow'),
            numbers=TRUE, sortVars=TRUE,
            labels=names(airquality), cex.axis=.7,
            gap=3, ylab=c("Missing data","Pattern"))
```

```
 Variables sorted by number of missings:
 Variable      Count
    Ozone 0.24183007
  Solar.R 0.04575163
     Wind 0.00000000
     Temp 0.00000000
    Month 0.00000000
      Day 0.00000000
>
```



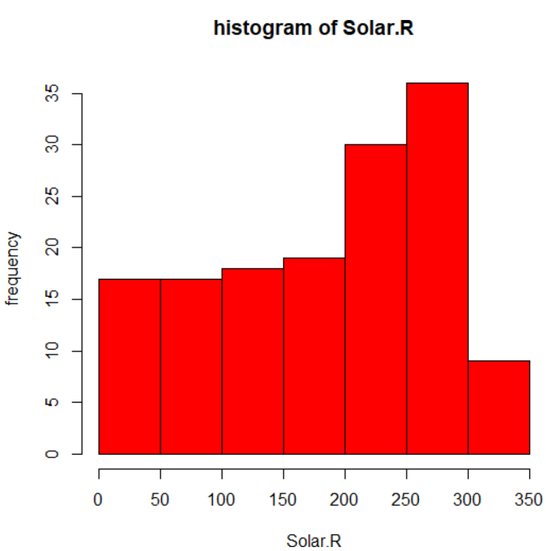
```
# In this case we are using predictive mean matching as imputation method
imputed_Data <- mice(airquality, m=5, maxit = 50, method = 'pmm', seed = 500)
summary(imputed_Data)
completeData <- complete(imputed_Data)
completeData
```

```
> summary(imputed_Data)
Class: mids
Number of multiple imputations:  5
Imputation methods:
  Ozone Solar.R    Wind    Temp   Month     Day
  "pmm"   "pmm"      ""      ""      ""      ""
PredictorMatrix:
        Ozone Solar.R Wind Temp Month Day
Ozone       0       1    1    1     1   1
Solar.R     1       0    1    1     1   1
Wind        1       1    0    1     1   1
Temp        1       1    1    0     1   1
Month       1       1    1    1     0   1
Day         1       1    1    1     1   0
>
```

	Ozone	Solar.R	Wind	Temp	Month	Day
1	41	190	7.4	67	5	1
2	36	118	8.0	72	5	2
3	12	149	12.6	74	5	3
4	18	313	11.5	62	5	4
5	6	115	14.3	56	5	5
6	28	274	14.9	66	5	6
7	23	299	8.6	65	5	7
8	19	99	13.8	59	5	8
9	8	19	20.1	61	5	9
10	12	194	8.6	69	5	10
11	7	275	6.9	74	5	11
12	16	256	9.7	69	5	12
13	11	290	9.2	66	5	13
14	14	274	10.9	68	5	14
15	18	65	13.2	58	5	15

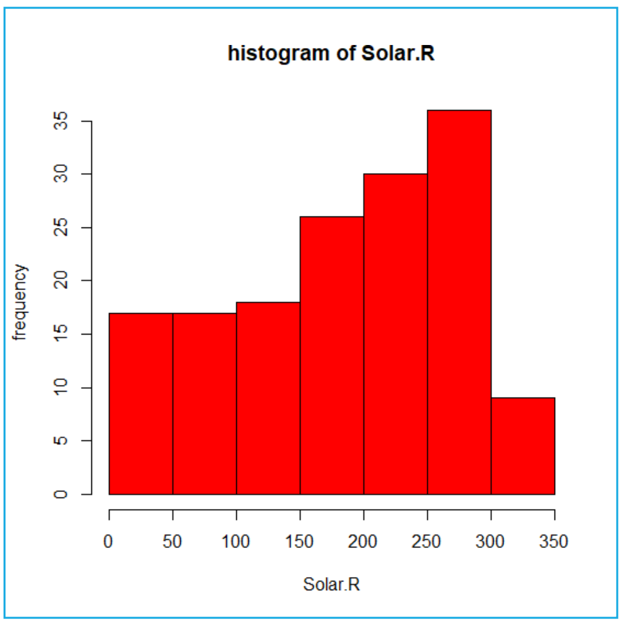
```
#or we an alternate way do it for variable Solar.R in airquality dataset
newair =airquality

dim(newair)
str(newair)
summary(newair)
#before imputing
hist(newair$Solar.R ,xlab = "Solar.R", ylab = "frequency",main="histogram of
Solar.R",col="red")

mean(newair$Solar.R)
mean(newair$Solar.R,na.rm = T)
```

```
> dim(newair)
[1] 153   6
> str(newair)
'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 ...
> summary(newair)
     Ozone           Solar.R           Wind             Temp           Month            Day      
 Min.   :  1.00   Min.   :  7.0   Min.   : 1.700   Min.   :56.00   Min.   :5.000   Min.   : 1.0  
 1st Qu.: 18.00   1st Qu.:115.8   1st Qu.: 7.400   1st Qu.:72.00   1st Qu.:6.000   1st Qu.: 8.0  
 Median : 31.50   Median :205.0   Median : 9.700   Median :79.00   Median :7.000   Median :16.0  
 Mean   : 42.13   Mean   :185.9   Mean   : 9.958   Mean   :77.88   Mean   :6.993   Mean   :15.8  
 3rd Qu.: 63.25   3rd Qu.:258.8   3rd Qu.:11.500   3rd Qu.:85.00   3rd Qu.:8.000   3rd Qu.:23.0  
 Max.   :168.00   Max.   :334.0   Max.   :20.700   Max.   :97.00   Max.   :9.000   Max.   :31.0  
 NA's   :37       NA's   :7                                                                       
> #before imputing
> hist(newair$Solar.R ,xlab = "Solar.R", ylab = "frequency",main="histogram of Solar.R",col="red")
> mean(newair$Solar.R)
[1] NA
> mean(newair$Solar.R,na.rm = T)
[1] 185.9315
>
```



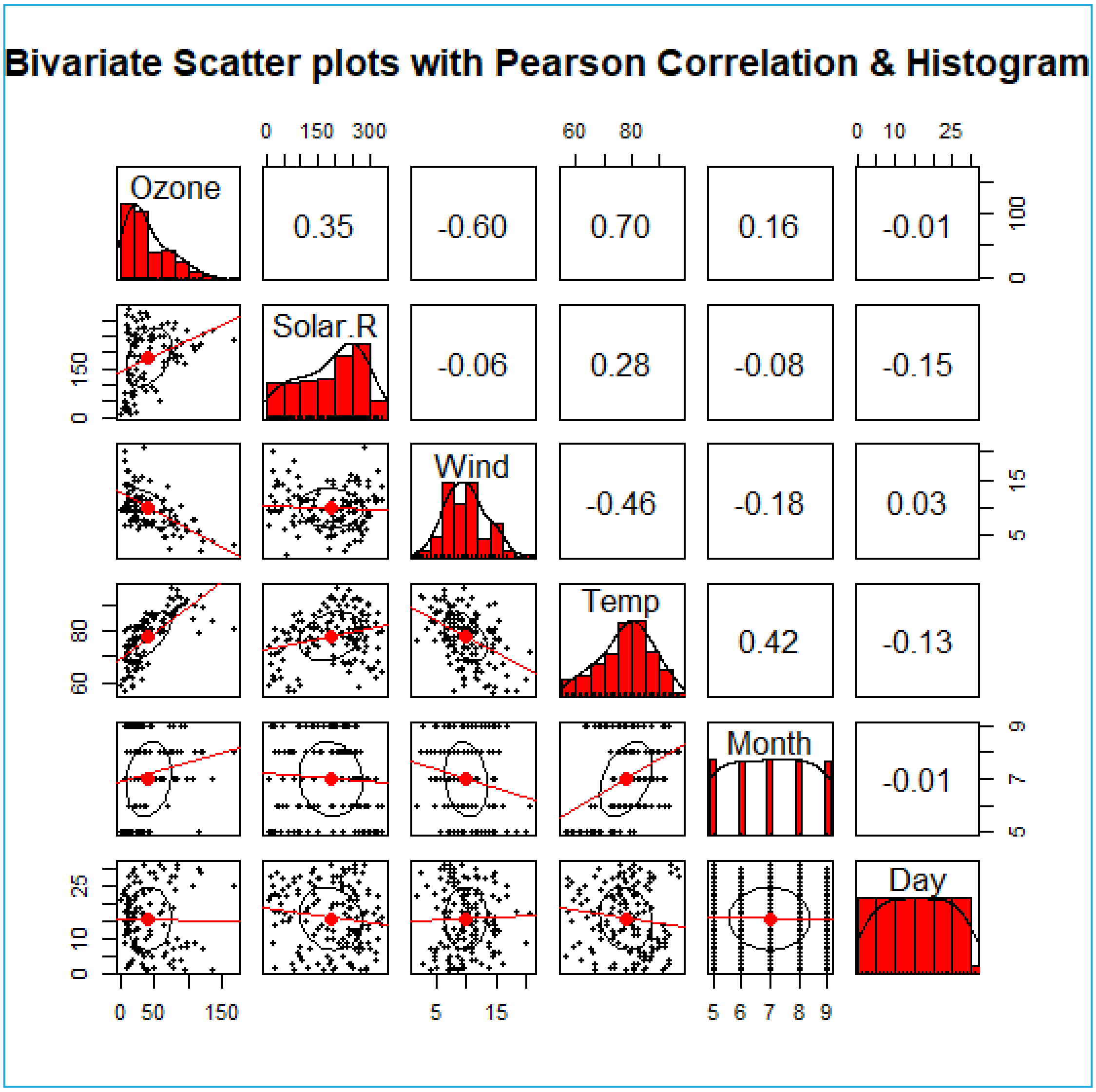
```
#imputed my mean
newair$Solar.R[is.na(newair$Solar.R)]<- mean(newair$Solar.R,na.rm = T)

#check summary after done with imputing
summary(newair)
newair$Solar.R

#visualize after imputing the variable Solar.R with the mean
#lets visualize through histogram
#after imputing
hist(newair$Solar.R ,xlab = "Solar.R", ylab = "frequency",main="histogram of 
Solar.R",col="red")
```

```
> #imputed my mean
> newair$Solar.R[is.na(newair$Solar.R)]<- mean(newair$Solar.R,na.rm = T)
> #check summary after done with imputing
> summary(newair)
     Ozone            Solar.R           Wind             Temp           Month            Day      
 Min.   :  1.00   Min.   :  7.0   Min.   : 1.700   Min.   :56.00   Min.   :5.000   Min.   : 1.0  
 1st Qu.: 18.00   1st Qu.:120.0   1st Qu.: 7.400   1st Qu.:72.00   1st Qu.:6.000   1st Qu.: 8.0  
 Median : 31.50   Median :194.0   Median : 9.700   Median :79.00   Median :7.000   Median :16.0  
 Mean   : 42.13   Mean   :185.9   Mean   : 9.958   Mean   :77.88   Mean   :6.993   Mean   :15.8  
 3rd Qu.: 63.25   3rd Qu.:256.0   3rd Qu.:11.500   3rd Qu.:85.00   3rd Qu.:8.000   3rd Qu.:23.0  
 Max.   :168.00   Max.   :334.0   Max.   :20.700   Max.   :97.00   Max.   :9.000   Max.   :31.0  
 NA's   :37                                                                                       
> newair$Solar.R
  [1] 190.0000 118.0000 149.0000 313.0000 185.9315 185.9315 299.0000  99.0000  19.0000 194.0000 185.9315 256.0000 290.0000 274.0000  65.0000 334.0000 307.0000
 [18]  78.0000 322.0000  44.0000   8.0000 320.0000  25.0000  92.0000  66.0000 266.0000 185.9315  13.0000 252.0000 223.0000 279.0000 286.0000 287.0000 242.0000
 [35] 186.0000 220.0000 264.0000 127.0000 273.0000 291.0000 323.0000 259.0000 250.0000 148.0000 332.0000 322.0000 191.0000 284.0000  37.0000 120.0000 137.0000
 [52] 150.0000  59.0000  91.0000 250.0000 135.0000 127.0000  47.0000  98.0000  31.0000 138.0000 269.0000 248.0000 236.0000 101.0000 175.0000 314.0000 276.0000
 [69] 267.0000 272.0000 175.0000 139.0000 264.0000 175.0000 291.0000  48.0000 260.0000 274.0000 285.0000 187.0000 220.0000   7.0000 258.0000 295.0000 294.0000
 [86] 223.0000  81.0000  82.0000 213.0000 275.0000 253.0000 254.0000  83.0000  24.0000  77.0000 185.9315 185.9315 185.9315 255.0000 229.0000 207.0000 222.0000
[103] 137.0000 192.0000 273.0000 157.0000  64.0000  71.0000  51.0000 115.0000 244.0000 190.0000 259.0000  36.0000 255.0000 212.0000 238.0000 215.0000 153.0000
[120] 203.0000 225.0000 237.0000 188.0000 167.0000 197.0000 183.0000 189.0000  95.0000  92.0000 252.0000 220.0000 230.0000 259.0000 236.0000 259.0000 238.0000
[137]  24.0000 112.0000 237.0000 224.0000  27.0000 238.0000 201.0000 238.0000  14.0000 139.0000  49.0000  20.0000 193.0000 145.0000 191.0000 131.0000 223.0000
> #after imputing
> hist(newair$Solar.R ,xlab = "Solar.R", ylab = "frequency",main="histogram of Solar.R",col="red")
> 
```



e. Create bi-variate analysis for all relationships

```
library(psych)
pairs.panels( airquality[,c(1,2,3,4,5,6)],
        method = "pearson", # correlation method
        hist.col = "red",
        density = TRUE, # show density plots
        ellipses = TRUE, # show correlation ellipses
        lm=TRUE,
        main ="Bivariate Scatter plots with Pearson Correlation & Histogram"
)
```



f. Test relevant hypothesis for valid relations

```
#lets find out the structure
str(airquality)
#we do paired test for continous variables
#some of test are as follows
#define the null hypothesis
#Ho: Mean of first variable - Mean of 2 variable is equal to 0
#Ha: Mean of first variable - Mean of 2 variable is not equal to 0
t.test(x=airquality$Ozone, y=airquality$Solar.R ,alternative = "two.sided",mu=0 ,paired = TRUE)
t.test(x=airquality$Temp, y=airquality$Wind ,alternative = "two.sided",mu=0 ,paired = TRUE)
t.test(x=airquality$Ozone, y=airquality$Temp ,alternative = "two.sided",mu=0 ,paired = TRUE)
t.test(x=airquality$Day, y=airquality$Solar.R ,alternative = "two.sided",mu=0 ,paired = TRUE)

#as p value of this test is <0.05 we reject the null hypo
#and accept the alternative hypothesis which says there
#Mean of 1 variable - Mean of 2 variable is not equal to 0
#thus this are some test that we performed
```

```
        Paired t-test

data:  airquality$Ozone and airquality$Solar.R
t = -17.593, df = 110, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -158.7772 -126.6282
sample estimates:
mean of the differences
              -142.7027

> t.test(x=airquality$Temp, y=airquality$Wind ,alternative = "two.sided",mu=0 ,paired = TRUE)

        Paired t-test

data:  airquality$Temp and airquality$Wind
t = 72.978, df = 152, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 66.08593 69.76374
sample estimates:
mean of the differences
               67.92484
```

```
> t.test(x=airquality$Ozone, y=airquality$Temp ,alternative = "two.sided",mu=0 ,paired = TRUE)

        Paired t-test

data:  airquality$Ozone and airquality$Temp
t = -14.14, df = 115, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -40.74819 -30.73457
sample estimates:
mean of the differences
              -35.74138

> t.test(x=airquality$Day, y=airquality$Solar.R ,alternative = "two.sided",mu=0 ,paired = TRUE)

        Paired t-test

data:  airquality$Day and airquality$Solar.R
t = -22.353, df = 145, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -184.8230 -154.7934
sample estimates:
mean of the differences
              -169.8082
```

g. Create cross tabulations with derived variables

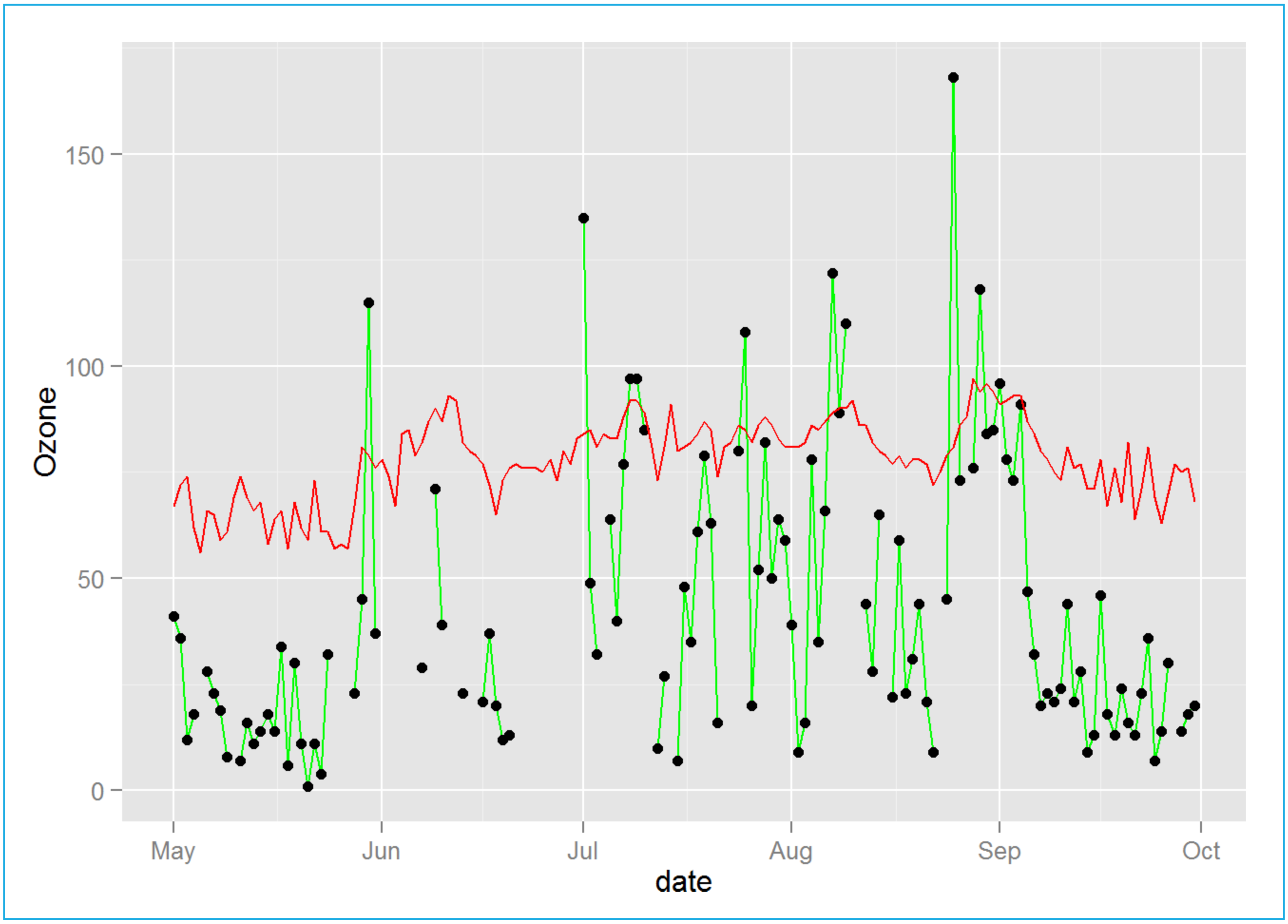
```
attach(airquality)
unique(Wind)
unique(Temp)

#derived variables of wind and temp
x<- cut(Wind,quantile(Wind))
x<- cut(Wind,breaks = seq(1,21,3),labels =
c("wind1","wind2","wind3","wind4","wind5","wind6")) y<- cut(Temp,quantile(Temp))
y<- cut(Temp,breaks = seq(55,100,9),labels = c("temp1","temp2","temp3","temp4","temp5"))
table(x,y)
#or like this using xtabs function
mytable<- xtabs(~x+y,data = airquality)
mytable
#crosstabulate
library(gmodels)
CrossTable(x,y)
```

```
> unique(Wind)
 [1]  7.4  8.0 12.6 11.5 14.3 14.9  8.6 13.8 20.1  6.9  9.7  9.2 10.9 13.2 12.0 18.4 16.6  5.7 16.1 20.7 10.3  6.3  1.7  4.6  4.1  5.1  4.0 15.5  3.4  2.3  2.8
> unique(Temp)
 [1] 67 72 74 62 56 66 65 59 61 69 68 58 64 57 73 81 79 76 78 84 85 82 87 90 93 92 80 77 75 83 88 89 91 86 97 94 96 71 63 70
> #derived variables of wind and temp
> x<- cut(Wind,quantile(Wind))
> x<- cut(Wind,breaks = seq(1,21,3),labels = c("wind1","wind2","wind3","wind4","wind5","wind6"))
> y<- cut(Temp,quantile(Temp))
> y<- cut(Temp,breaks = seq(55,100,9),labels = c("temp1","temp2","temp3","temp4","temp5"))
> table(x,y)
       y
x       temp1 temp2 temp3 temp4 temp5
  wind1     0     0     2     1     2
  wind2     0     1    11    10     6
  wind3     4     9    18    14     3
  wind4     4    11    17     8     1
  wind5     4     4    13     3     0
  wind6     3     2     0     0     0
> #or like this using xtabs function
> mytable<- xtabs(~x+y,data = airquality)
> mytable
       y
x       temp1 temp2 temp3 temp4 temp5
  wind1     0     0     2     1     2
  wind2     0     1    11    10     6
  wind3     4     9    18    14     3
  wind4     4    11    17     8     1
  wind5     4     4    13     3     0
  wind6     3     2     0     0     0
> 
```

```
   Cell Contents
|-------------------------|
|                       N |
| Chi-square contribution |
|           N / Row Total |
|           N / Col Total |
|         N / Table Total |
|-------------------------|


Total Observations in Table:  151


             | y
           x |     temp1 |     temp2 |     temp3 |     temp4 |     temp5 | Row Total |
-------------|-----------|-----------|-----------|-----------|-----------|-----------|
       wind1 |         0 |         0 |         2 |         1 |         2 |         5 |
             |     0.497 |     0.894 |     0.000 |     0.031 |     6.464 |           |
             |     0.000 |     0.000 |     0.400 |     0.200 |     0.400 |     0.033 |
             |     0.000 |     0.000 |     0.033 |     0.028 |     0.167 |           |
             |     0.000 |     0.000 |     0.013 |     0.007 |     0.013 |           |
-------------|-----------|-----------|-----------|-----------|-----------|-----------|
       wind2 |         0 |         1 |        11 |        10 |         6 |        28 |
             |     2.781 |     3.206 |     0.009 |     1.656 |     6.404 |           |
             |     0.000 |     0.036 |     0.393 |     0.357 |     0.214 |     0.185 |
             |     0.000 |     0.037 |     0.180 |     0.278 |     0.500 |           |
             |     0.000 |     0.007 |     0.073 |     0.066 |     0.040 |           |
-------------|-----------|-----------|-----------|-----------|-----------|-----------|
       wind3 |         4 |         9 |        18 |        14 |         3 |        48 |
             |     0.124 |     0.020 |     0.100 |     0.571 |     0.174 |           |
             |     0.083 |     0.188 |     0.375 |     0.292 |     0.062 |     0.318 |
             |     0.267 |     0.333 |     0.295 |     0.389 |     0.250 |           |
             |     0.026 |     0.060 |     0.119 |     0.093 |     0.020 |           |
-------------|-----------|-----------|-----------|-----------|-----------|-----------|
       wind4 |         4 |        11 |        17 |         8 |         1 |        41 |
             |     0.001 |     1.836 |     0.012 |     0.322 |     1.565 |           |
             |     0.098 |     0.268 |     0.415 |     0.195 |     0.024 |     0.272 |
             |     0.267 |     0.407 |     0.279 |     0.222 |     0.083 |           |
             |     0.026 |     0.073 |     0.113 |     0.053 |     0.007 |           |
-------------|-----------|-----------|-----------|-----------|-----------|-----------|
       wind5 |         4 |         4 |        13 |         3 |         0 |        24 |
             |     1.095 |     0.020 |     1.126 |     1.295 |     1.907 |           |
             |     0.167 |     0.167 |     0.542 |     0.125 |     0.000 |     0.159 |
             |     0.267 |     0.148 |     0.213 |     0.083 |     0.000 |           |
             |     0.026 |     0.026 |     0.086 |     0.020 |     0.000 |           |
-------------|-----------|-----------|-----------|-----------|-----------|-----------|
       wind6 |         3 |         2 |         0 |         0 |         0 |         5 |
             |    12.617 |     1.368 |     2.020 |     1.192 |     0.397 |           |
             |     0.600 |     0.400 |     0.000 |     0.000 |     0.000 |     0.033 |
             |     0.200 |     0.074 |     0.000 |     0.000 |     0.000 |           |
             |     0.020 |     0.013 |     0.000 |     0.000 |     0.000 |           |
-------------|-----------|-----------|-----------|-----------|-----------|-----------|
Column Total |        15 |        27 |        61 |        36 |        12 |       151 |
             |     0.099 |     0.179 |     0.404 |     0.238 |     0.079 |           |
-------------|-----------|-----------|-----------|-----------|-----------|-----------|
```

h. **check for trends and patterns in time series**

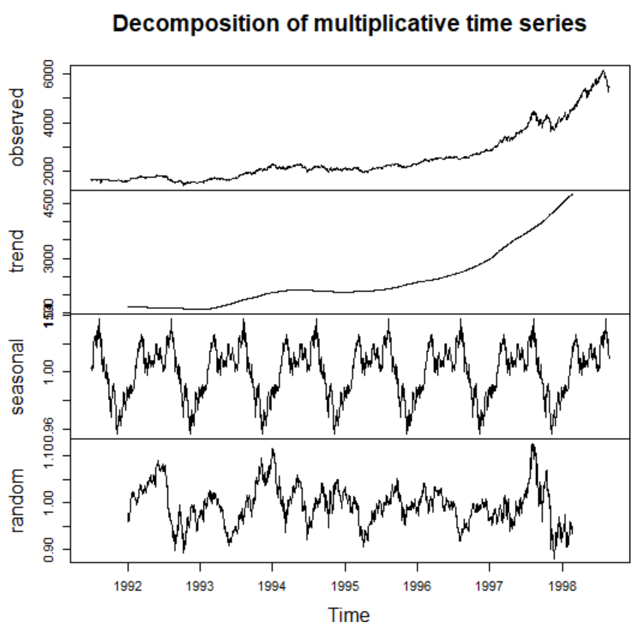
ggplot(airquality, aes(x = (Month * 100 + Day), y = Ozone)) + geom_line() + geom_point()



```
ts (AirQualityUCI, frequency = 4, start = c(1959, 2)) # frequency 4 => Quarterly Data
ts (1:10, frequency = 12, start = 1990) # freq 12 => Monthly data.
ts (AirQualityUCI, start=c(2009), end=c(2014), frequency=1) # Yearly Data
ts (1:1000, frequency = 365, start = 1990)# freq 365 => daily data.
tsAirqualityUCI <- EuStockMarkets[, 1] # ts data copied some time series data as below
```

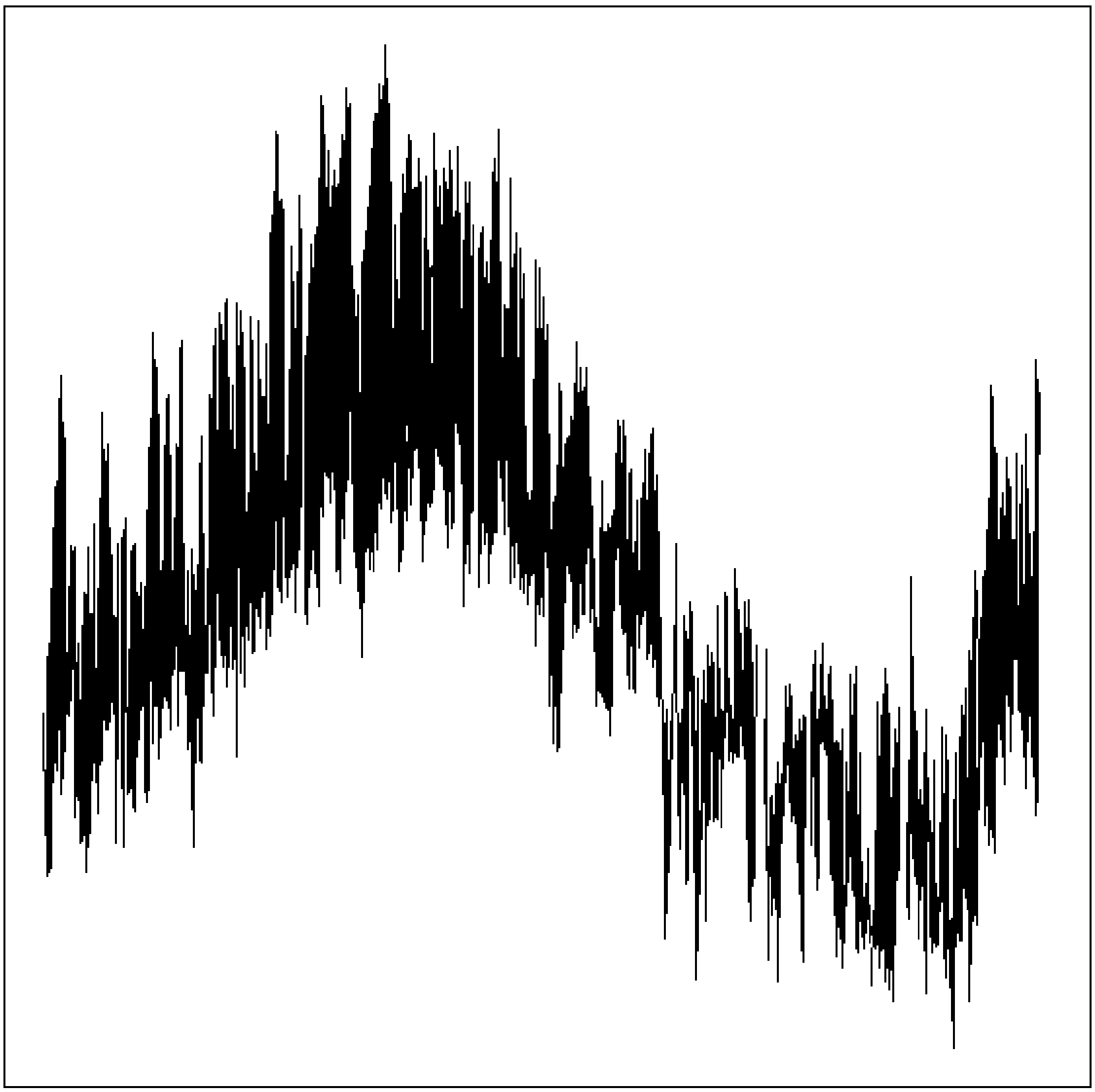
```
> #8. Check for trends and patterns in time series.
> ts (AirQualityUCI, frequency = 4, start = c(1959, 2)) # frequency 4 => Quarterly Data
        Date Time CO(GT) PT08.S1(CO) NMHC(GT) C6H6(GT) PT08.S2(NMHC) NOx(GT) PT08.S3(NOx) NO2(GT) PT08.S4(NO2) PT08.S5(O3)    T  RH AH X16 X17
1959 Q2   NA   NA     NA        1360      150       NA          1046     166         1056     113         1692        1268 136 489 NA  NA  NA
1959 Q3   NA   NA      2        1292      112       NA           955     103         1174      92         1559         972 133 477 NA  NA  NA
1959 Q4   NA   NA     NA        1402       88       NA           939     131         1140     114         1555        1074 119 540 NA  NA  NA
1960 Q1   NA   NA     NA        1376       80       NA           948     172         1092     122         1584        1203 110 600 NA  NA  NA
1960 Q2   NA   NA     NA        1272       51       NA           836     131         1205     116         1490        1110 112 596 NA  NA  NA
1960 Q3   NA   NA     NA        1197       38       NA           750      89         1337      96         1393         949 112 592 NA  NA  NA
1960 Q4   NA   NA     NA        1185       31       NA           690      62         1462      77         1333         733 113 568 NA  NA  NA
1961 Q1   NA   NA      1        1136       31       NA           672      62         1453      76         1333         730 107 600 NA  NA  NA
1961 Q2   NA   NA     NA        1094       24       NA           609      45         1579      60         1276         620 107 597 NA  NA  NA
1961 Q3   NA   NA     NA        1010       19       NA           561      NA         1705      NA         1235         501 103 602 NA  NA  NA
1961 Q4   NA   NA     NA        1011       14       NA           527      21         1818      34         1197         445 101 605 NA  NA  NA
1962 Q1   NA   NA     NA        1066        8       NA           512      16         1918      28         1182         422 110 562 NA  NA  NA
1962 Q2   NA   NA     NA        1052       16       NA           553      34         1738      48         1221         472 105 581 NA  NA  NA
1962 Q3   NA   NA     NA        1144       29       NA           667      98         1490      82         1339         730 102 596 NA  NA  NA
1962 Q4   NA   NA      2        1333       64       NA           900     174         1136     112         1517        1102 108 574 NA  NA  NA
1963 Q1   NA   NA     NA        1351       87       NA           960     129         1079     101         1583        1028 105 606 NA  NA  NA
1963 Q2   NA   NA     NA        1233       77       NA           827     112         1218      98         1446         860 108 584 NA  NA  NA
1963 Q3   NA   NA     NA        1179       43       NA           762      95         1328      92         1362         671 105 579 NA  NA  NA
1963 Q4   NA   NA     NA        1236       61       NA           774     104         1301      95         1401         664  95 668 NA  NA  NA
1964 Q1   NA   NA     NA        1286       63       NA           869     146         1162     112         1537         799  83 764 NA  NA  NA
1964 Q2   NA   NA     NA        1371      164       NA          1034     207          983     128         1730        1037  80 811 NA  NA  NA
1964 Q3   NA   NA     NA        1310       79       NA           933     184         1082     126         1647         946  83 798 NA  NA  NA
1964 Q4   NA   NA     NA        1292       95       NA           912     193         1103     131         1591         957  97 712 NA  NA  NA
1965 Q1   NA   NA     NA        1383      150       NA          1020     243         1008     135         1719        1104  98 676 NA  NA  NA
1965 Q2   NA   NA     NA        1581      307       NA          1319     281          799     151         2083        1409 103 642 NA  NA  NA
1965 Q3   NA   NA     NA        1776      461       NA          1488     383          702     172         2333        1704  97 693 NA  NA  NA
1965 Q4   NA   NA     NA        1640      401       NA          1404     351          743     165         2191        1654  96 678 NA  NA  NA
1966 Q1   NA   NA     NA        1313      197       NA          1076     240          957     136         1707        1285  91 640 NA  NA  NA
1966 Q2   NA   NA     NA         965       61       NA           749      94         1325      85         1333         821  82 634 NA  NA  NA
```

```
> ts (1:10, frequency = 12, start = 1990) # freq 12 => Monthly data.
     Jan Feb Mar Apr May Jun Jul Aug Sep Oct
1990   1   2   3   4   5   6   7   8   9  10
> ts (AirQualityUCI, start=c(2009), end=c(2014), frequency=1) # Yearly Data
Time Series:
Start = 2009
End = 2014
Frequency = 1
     Date Time CO(GT) PT08.S1(CO) NMHC(GT) C6H6(GT) PT08.S2(NMHC) NOx(GT) PT08.S3(NOx) NO2(GT) PT08.S4(NO2) PT08.S5(O3)    T  RH AH X16 X17
2009   NA   NA     NA        1360      150       NA          1046     166         1056     113         1692        1268 136 489 NA  NA  NA
2010   NA   NA      2        1292      112       NA           955     103         1174      92         1559         972 133 477 NA  NA  NA
2011   NA   NA     NA        1402       88       NA           939     131         1140     114         1555        1074 119 540 NA  NA  NA
2012   NA   NA     NA        1376       80       NA           948     172         1092     122         1584        1203 110 600 NA  NA  NA
2013   NA   NA     NA        1272       51       NA           836     131         1205     116         1490        1110 112 596 NA  NA  NA
2014   NA   NA     NA        1197       38       NA           750      89         1337      96         1393         949 112 592 NA  NA  NA
Warning messages:
1: In data.matrix(data) : NAs introduced by coercion
2: In data.matrix(data) : NAs introduced by coercion
3: In data.matrix(data) : NAs introduced by coercion
4: In data.matrix(data) : NAs introduced by coercion
5: In data.matrix(data) : NAs introduced by coercion
>
```



i. Find out the most polluted time of the day and the name of the chemical compound.

```
tsAirqualityUCI <- EuStockMarkets[, 1] # ts data
decomposedRes <- decompose(tsAirqualityUCI, type="mult") # use type = "additive" for additive components
plot (decomposedRes) # see plot below
stlRes <- stl(tsAirqualityUCI, s.window = "periodic")
plot(AirQualityUCI$T, type = "l")
```



Date	Time	NOx(GT)	PT08.S3(NOx)	NO2(GT)	PT08.S4(NO2)	PT08.S5(O3)
6/8/2004	8:00:00	376	525	125	2746	1708
6/9/2004	8:00:00	357	507	151	2691	2147
10/26/2004	18:00:00	952	325	180	2775	2372
max		1479.0	2682.8	339.7	2775.0	2522.8

Date	Time	CO(GT)	PT08.S1(CO)	NMHC(GT)	C6H6(GT)	PT08.S2(NMHC)
6/8/2004	8:00:00	5.8	1377	-200	36.1	1688
6/9/2004	8:00:00	6.4	1496	-200	36.9	1705
10/26/2004	18:00:00	9.5	1908	-200	52.1	2007
Max		11.9	2039.8	1189.0	63.7	2214.0

Date	Time	NOx(GT)	PT08.S3(NOx)	NO2(GT)	PT08.S4(NO2)	PT08.S5(O3)
6/8/2004	8:00:00	376	525	125	2746	1708
6/9/2004	8:00:00	357	507	151	2691	2147
10/26/2004	18:00:00	952	325	180	2775	2372
max		1479.0	2682.8	339.7	2775.0	2522.8