Assignment 1

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Exercise 1. Post-operative nausea.

The file contains data about post-operative nausea after medication against nausea. Two different medicines were administered to patients that complained about post-operative nausea. One of the medicines, Pentobarbital, was administered in two different doses.

```
nausea_df <- read.table("data/nauseatable.txt", header=TRUE)
nausea_df
```

```
##                     Incidence.of.no.nausea Incidence.of.Nausea
## Chlorpromazine                         100                  52
## Pentobarbital(100mg)                    32                  35
## Pentobarbital(150mg)                    48                  37
```

a) Discuss whether a contingency table test is appropriate here. If yes, perform this test in order to test whether the different medicines work equally well against nausea. Where are the main inconsistencies?

There are two factors: presence of nausea and the medication. For each combination of factors, the number of cases are registered. Contingency table test is applicable in terms of the task to find the dependency between the factors. For that a specific condition has to be met.

```
z=chisq.test(nausea_df)
z
```

```
##
##  Pearson's Chi-squared test
##
## data:  nausea_df
## X-squared = 6.6248, df = 2, p-value = 0.03643
```

There are no contraindications for the chi-square test. The test concludes that there is a dependence between row and column variables. Let's check what is that difference.

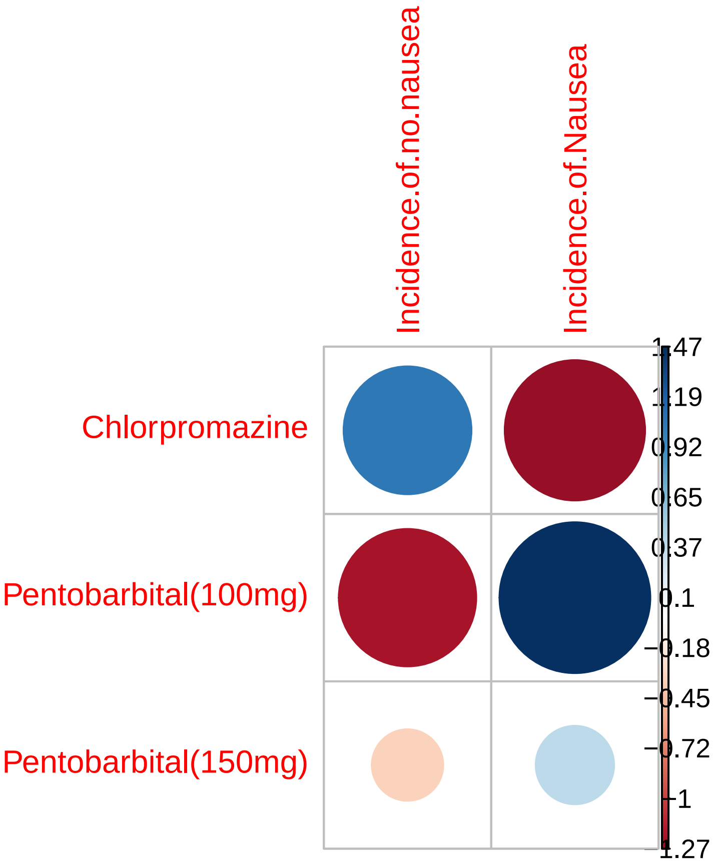
```
library(corrplot)
```

```
## corrplot 0.92 loaded
```

```
z$residuals
```

```
##                     Incidence.of.no.nausea Incidence.of.Nausea
## Chlorpromazine                      1.0540926          -1.270001
## Pentobarbital(100mg)               -1.2179181           1.467383
## Pentobarbital(150mg)               -0.3282848           0.395527
```

```
corrplot(z$residuals, is.cor = FALSE)
```



Chlorpromazine is relatevily more helpful in terms of fighting against nausea in comparison to both dosages of Pentobarbital. Also, 100mg of Pentobarbital has more nausea cases.

b) Perform a permutation test in order to test whether the different medicines work equally well against nausea. Permute the medicine labels for this purpose. Use as test statistic the chisquare test statistic for contingency tables, which can be extracted from the output of the command chisq.test. (Hint: make a data frame in R consisting of two columns. One column should contain an indicator whether or not the patient in that row suffered from nausea, and the other column should indicate the medicine.)

```
indicator_col <- c()
label_col <- c()
for(i in 1:3){
  indicator_col <- append(indicator_col, rep(0, nausea_df[i, 1]))
  indicator_col <- append(indicator_col, rep(1, nausea_df[i, 2]))
  label_col <- append(label_col, rep(rownames(nausea_df)[i], rowSums(nausea_df[i, ])))
}
```

```
nausea_two_col_df <- data.frame(indicator_col, label_col)
head(nausea_two_col_df)
```

```
##   indicator_col     label_col
## 1             0 Chlorpromazine
## 2             0 Chlorpromazine
## 3             0 Chlorpromazine
## 4             0 Chlorpromazine
## 5             0 Chlorpromazine
## 6             0 Chlorpromazine
```

```
mystat <- function(x) chisq.test(x)$statistic
B <- 1000
tstar <- numeric(B)
for(i in 1:B){
  perm_label <- sample(nausea_two_col_df$label_col) ## permuting the labels
  tstar[i] <- mystat(table(data.frame(nausea_two_col_df$indicator_col, perm_label)))
}
myt <- mystat(table(data.frame(nausea_two_col_df$indicator_col, nausea_two_col_df$label_col)))

pl <- sum(tstar<myt)/B
pr <- sum(tstar>myt)/B
p_perm <- min(pl, pr)
p_perm
```

```
## [1] 0.044
```

The permutation test rejects the null hypethesis that different medicines work equally well against nausea.

c) Compare the p-value found by the permutation test with the p-value found from the chisquare test for contingency tables. Explain the difference/equality of the two p-values.

Relaunch of the permutation test retrieves the p-value of about 0.03-0.04 while the p-value from the chi-square test is 0.036. The permutation test is completely suitable for such kind of tasks. It also reveals the same conclusion and similar p-value as the chi-square test.

Exercise 2. Airpollution.

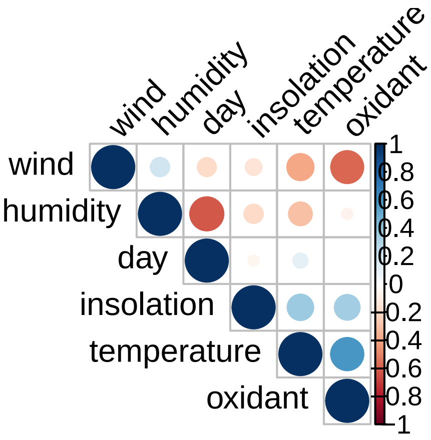
The data were obtained to determine predictors related to air pollution. We want to investigate which explanatory variables need to be included into a linear regression model with oxidant as the response variable.

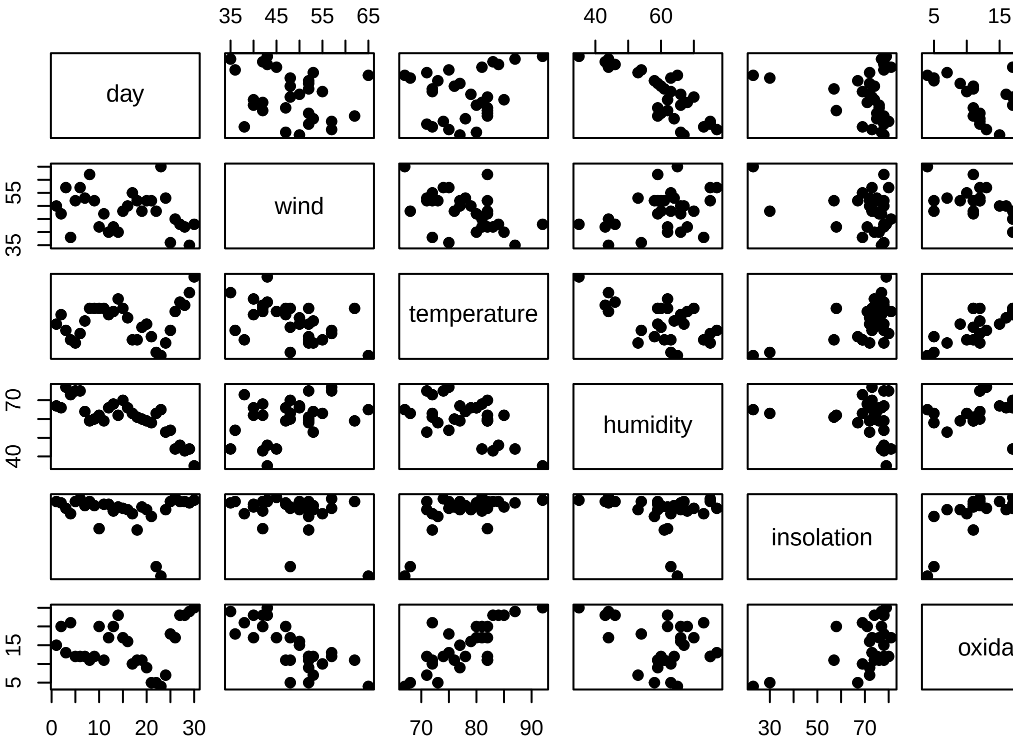
```
pollution_df <- read.table("data/airpollution.txt", header=TRUE)
head(pollution_df)
```

```
##   day wind temperature humidity insolation oxidant
## 1   1   50          77       67         78      15
## 2   2   47          80       66         77      20
## 3   3   57          75        77          73       13
## 4   4   38          72        73          69       21
## 5   5   52          71        75          78       12
## 6   6   57          74        75          80       12
```

a) Make some graphical summaries of the data. Investigate the problem of potential and influence points, and the problem of collinearity.

```
# cor(pollution_df, method = c("spearman"))
if (!require("corrplot")) install.packages("corrplot")
library(corrplot)
par(mfrow=c(2, 1))
res <- cor(pollution_df, method='kendall')
corrplot(res, type = "upper", order = "hclust",
         tl.col = "black", tl.srt = 45)
pairs(pollution_df, pch = 19)
```

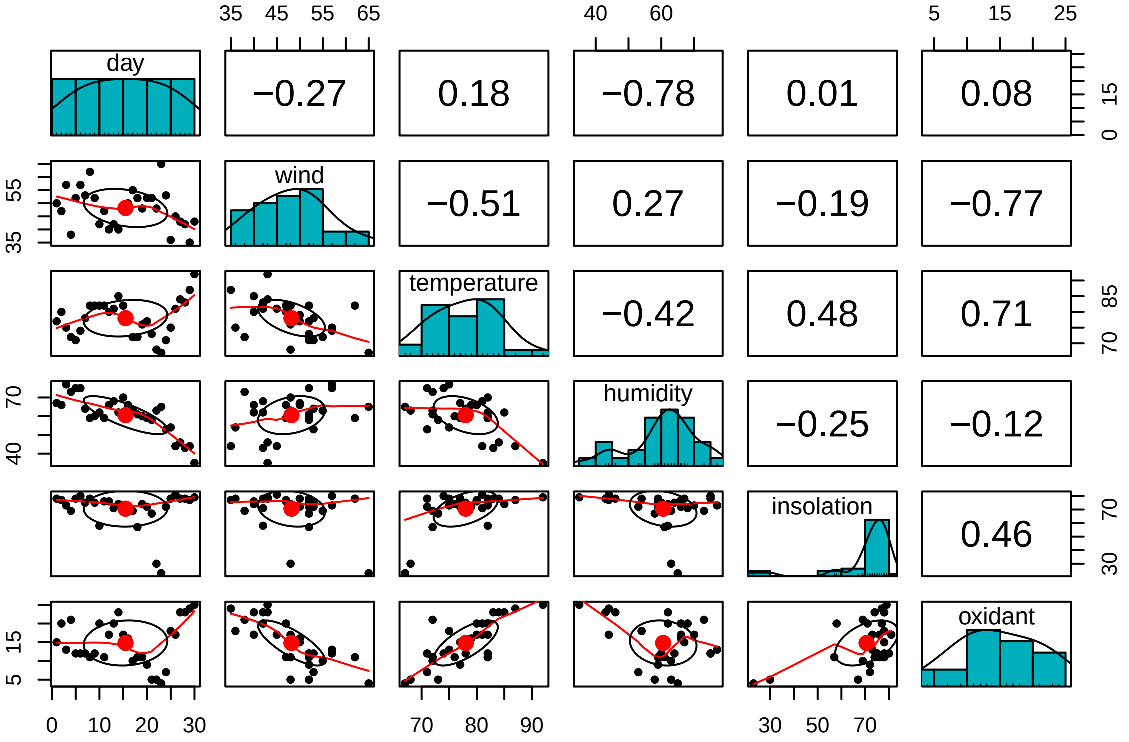




```
if (!require("psych")) install.packages("psych")
```

```
## Loading required package: psych
```

```
library(psych)
pairs.panels(pollution_df,
             method = "spearman", # correlation method
             hist.col = "#00AFBB",
             density = TRUE,  # show density plots
             ellipses = TRUE # show correlation ellipses
             )
```

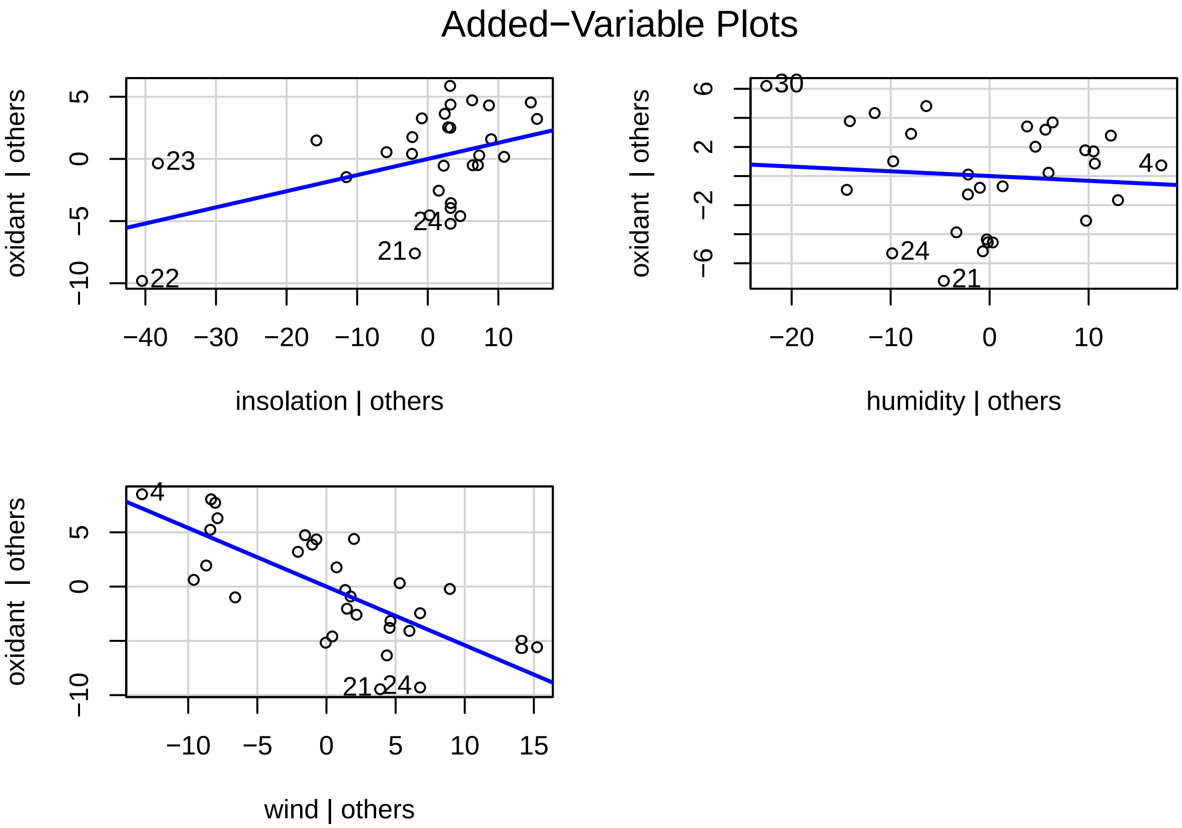


b) Use the added variable plot to depict the relationship between response oxidant and predictor wind. What is the meaning of the slope of fitted regression for this scatter plot?

```r
if (!require("car")) install.packages("car")
```

```
## Loading required package: car

## Loading required package: carData

##
## Attaching package: 'car'

## The following object is masked from 'package:psych':
##
##     logit
```

```r
library(car)

attach(pollution_df)
mod = lm(oxidant~insolation+humidity+wind)
par(mfrow=c(2, 1))
avPlots(mod)
```



```
summary(mod)
```

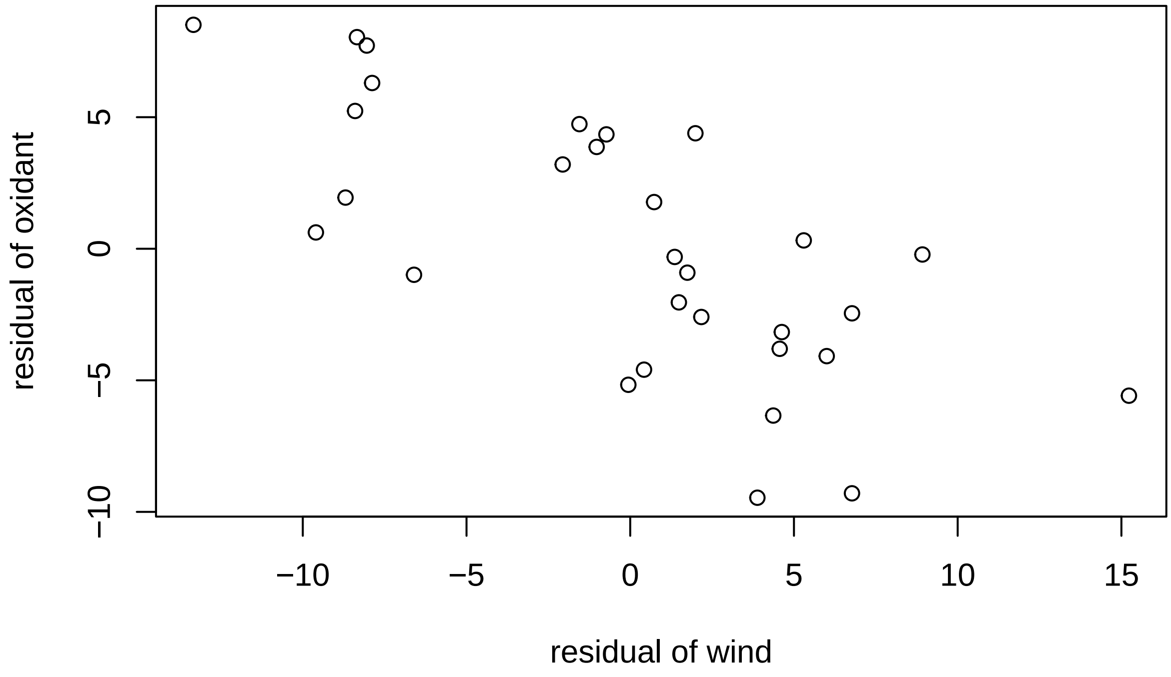
```
##
## Call:
## lm(formula = oxidant ~ insolation + humidity + wind)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -7.3630 -2.4212  0.5585  3.0466  5.4644
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 33.65768    7.67492   4.385  0.00017 ***
## insolation   0.12984    0.05479   2.370  0.02550 *
## humidity    -0.03266    0.07288  -0.448  0.65775
## wind        -0.54037    0.10550  -5.122 2.44e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.693 on 26 degrees of freedom
## Multiple R-squared:  0.6639, Adjusted R-squared:  0.6251
## F-statistic: 17.12 on 3 and 26 DF,  p-value: 2.423e-06
```

The slopes on the plots reflect the regression coefficients from the original miltiple regression model mod.

```
attach(pollution_df)
```

```
## The following objects are masked from pollution_df (pos = 3):
##
##     day, humidity, insolation, oxidant, temperature, wind
```

```
y = residuals(lm(oxidant~insolation+humidity))
x = residuals(lm(wind~insolation+humidity))
plot(x, y, xlab='residual of wind', ylab='residual of oxidant')
```



c) Fit a linear regression model to the data. Use both the step-up and step-down methods to find the best model. If step-up and step-down yield two different models, choose one and motivate your choice.

```
for(i in names(pollution_df)){
  if(i == 'oxidant'){next}
  # summary(lm(oxidant~i))
  print(summary(lm(paste('pollution_df$oxidant',  '~pollution_df$', i))))
}
```

Step-up

```
##
## Call:
## lm(formula = paste("pollution_df$oxidant", "~pollution_df$",
##     i))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -11.3373  -3.8537   0.1298   5.5403   9.1613
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)      13.68966    2.28580   5.989 1.89e-06 ***
## pollution_df$day  0.07164    0.12876   0.556    0.582
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 6.104 on 28 degrees of freedom
## Multiple R-squared:  0.01093,    Adjusted R-squared:  -0.02439
## F-statistic: 0.3095 on 1 and 28 DF,  p-value: 0.5824
##
##
## Call:
## lm(formula = paste("pollution_df$oxidant", "~pollution_df$",
##     i))
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.9266 -2.5923  0.2065  2.6636  6.9077
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)        45.3171     4.8976   9.253 5.19e-10 ***
## pollution_df$wind  -0.6331     0.1005  -6.300 8.20e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.948 on 28 degrees of freedom
## Multiple R-squared:  0.5863, Adjusted R-squared:  0.5715
## F-statistic: 39.68 on 1 and 28 DF,  p-value: 8.205e-07
##
##
## Call:
## lm(formula = paste("pollution_df$oxidant", "~pollution_df$",
##     i))
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -6.9400 -2.2138  0.3775  2.5550 10.9099
##
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)              -46.4292     9.9542  -4.664 6.94e-05 ***
## pollution_df$temperature   0.7850     0.1273   6.168 1.17e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Residual standard error: 3.997 on 28 degrees of freedom
## Multiple R-squared:  0.576,  Adjusted R-squared:  0.5609
## F-statistic: 38.04 on 1 and 28 DF,  p-value: 1.167e-06
##
##
## Call:
## lm(formula = paste("pollution_df$oxidant", "~pollution_df$",
##     i))
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -10.3358  -4.0749   0.8782   4.7800   8.7957
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)            27.4446     6.4368   4.264 0.000206 ***
## pollution_df$humidity  -0.2088     0.1049  -1.991 0.056317 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.745 on 28 degrees of freedom
## Multiple R-squared:  0.124,  Adjusted R-squared:  0.09273
## F-statistic: 3.964 on 1 and 28 DF,  p-value: 0.05632
##
##
## Call:
## lm(formula = paste("pollution_df$oxidant", "~pollution_df$",
##     i))
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -8.9723 -4.4841 -0.3281  4.7631  8.2686
##
## Coefficients:
##                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)             -1.43279    5.32967  -0.269  0.79003
## pollution_df$insolation  0.22993    0.07424   3.097  0.00441 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.297 on 28 degrees of freedom
## Multiple R-squared:  0.2552, Adjusted R-squared:  0.2286
## F-statistic: 9.592 on 1 and 28 DF,  p-value: 0.004411
```

Wind variable gives maximum increase in the R^2. The variable is significant. Therefore, we can continue.

```
for(i in names(pollution_df)){
  if(i %in% c('oxidant', 'wind')){next}
  print(summary(lm(paste('pollution_df$oxidant',  '~pollution_df$wind+pollution_df$', i))))
}
```

```
## 
## Call:
## lm(formula = paste("pollution_df$oxidant", "~pollution_df$wind+pollution_df$", 
##     i))
## 
## Residuals:
##     Min      1Q  Median      3Q     Max 
## -9.4129 -2.5621  0.4498  2.3827  7.9267 
## 
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)    
## (Intercept)       47.84224    5.62785   8.501 4.10e-09 ***
## pollution_df$wind -0.65984    0.10489  -6.291 9.87e-07 ***
## pollution_df$day  -0.07986    0.08691  -0.919    0.366    
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 3.959 on 27 degrees of freedom
## Multiple R-squared:  0.5989, Adjusted R-squared:  0.5691 
## F-statistic: 20.15 on 2 and 27 DF,  p-value: 4.411e-06
## 
## 
## Call:
## lm(formula = paste("pollution_df$oxidant", "~pollution_df$wind+pollution_df$", 
##     i))
## 
## Residuals:
##     Min      1Q  Median      3Q     Max 
## -6.3939 -1.8608  0.5826  1.9461  4.9661 
## 
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)    
## (Intercept)              -5.20334   11.11810  -0.468    0.644    
## pollution_df$wind        -0.42706    0.08645  -4.940 3.58e-05 ***
## pollution_df$temperature  0.52035    0.10813   4.812 5.05e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 2.95 on 27 degrees of freedom
## Multiple R-squared:  0.7773, Adjusted R-squared:  0.7608 
## F-statistic: 47.12 on 2 and 27 DF,  p-value: 1.563e-09
## 
```

```
##
## Call:
## lm(formula = paste("pollution_df$oxidant", "~pollution_df$wind+pollution_df$",
##     i))
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.8120 -2.2808  0.3433  3.0476  5.8757
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)           46.91570    5.68573   8.251 7.38e-09 ***
## pollution_df$wind     -0.60955    0.10971  -5.556 6.86e-06 ***
## pollution_df$humidity -0.04516    0.07866  -0.574    0.571
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.996 on 27 degrees of freedom
## Multiple R-squared:  0.5913, Adjusted R-squared:  0.561
## F-statistic: 19.53 on 2 and 27 DF,  p-value: 5.674e-06
##
##
## Call:
## lm(formula = paste("pollution_df$oxidant", "~pollution_df$wind+pollution_df$",
##     i))
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -7.2119 -2.7198  0.4815  2.8733  6.2012
##
## Coefficients:
##                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)             32.32615    6.97098   4.637 8.07e-05 ***
## pollution_df$wind       -0.55639    0.09778  -5.690 4.81e-06 ***
## pollution_df$insolation  0.13161    0.05383   2.445   0.0213 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.638 on 27 degrees of freedom
## Multiple R-squared:  0.6613, Adjusted R-squared:  0.6362
## F-statistic: 26.36 on 2 and 27 DF,  p-value: 4.491e-07
```

Temperature variable works in the same way as the previous choice. Continue.

```
for(i in names(pollution_df)){
  if(i %in% c('oxidant', 'wind', 'temperature')){next}
  print(summary(lm(paste('pollution_df$oxidant',
                         '~pollution_df$wind',
                         '+pollution_df$temperature',
                         '+pollution_df$',
                         i))))
}
```

```
##
## Call:
## lm(formula = paste("pollution_df$oxidant", "~pollution_df$wind",
##     "+pollution_df$temperature", "+pollution_df$", i))
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -6.9010 -1.3477  0.1596  1.7766  3.9405
##
## Coefficients:
##                            Estimate Std. Error t value Pr(>|t|)
## (Intercept)              -2.98987   10.94466  -0.273    0.787
## pollution_df$wind        -0.45604    0.08644  -5.276 1.63e-05 ***
## pollution_df$temperature  0.52918    0.10568   5.008 3.29e-05 ***
## pollution_df$day         -0.09711    0.06328  -1.535    0.137
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.878 on 26 degrees of freedom
## Multiple R-squared:  0.7958, Adjusted R-squared:  0.7722
## F-statistic: 33.78 on 3 and 26 DF,  p-value: 4.042e-09
##
##
## Call:
## lm(formula = paste("pollution_df$oxidant", "~pollution_df$wind",
##     "+pollution_df$temperature", "+pollution_df$", i))
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -6.5887 -1.1686  0.1978  1.9004  4.1544
##
## Coefficients:
##                             Estimate Std. Error t value Pr(>|t|)
## (Intercept)              -16.60697   13.07154  -1.270    0.215
## pollution_df$wind         -0.44620    0.08513  -5.241 1.78e-05 ***
## pollution_df$temperature   0.60190    0.11764   5.117 2.47e-05 ***
## pollution_df$humidity      0.09850    0.06316   1.559    0.131
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.874 on 26 degrees of freedom
## Multiple R-squared:  0.7964, Adjusted R-squared:  0.7729
## F-statistic: 33.89 on 3 and 26 DF,  p-value: 3.904e-09
##
##
## Call:
## lm(formula = paste("pollution_df$oxidant", "~pollution_df$wind",
##     "+pollution_df$temperature", "+pollution_df$", i))
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -6.407 -2.056  1.012  1.760  4.792
##
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)              -4.45496   11.26714  -0.395 0.695778
## pollution_df$wind        -0.42353    0.08737  -4.848 5.02e-05 ***
## pollution_df$temperature  0.47558    0.12564   3.785 0.000816 ***
## pollution_df$insolation   0.03646    0.05071   0.719 0.478636
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.976 on 26 degrees of freedom
## Multiple R-squared:  0.7816, Adjusted R-squared:  0.7565
## F-statistic: 31.02 on 3 and 26 DF,  p-value: 9.583e-09
```

Humidity has the highest R-squared increase but the variable is not significant. Therefore, we don't add it to the model. Resulting model is:

```
print(summary(lm(pollution_df$oxidant~pollution_df$wind+pollution_df$temperature)))
```

```
##
## Call:
## lm(formula = pollution_df$oxidant ~ pollution_df$wind + pollution_df$temperature)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -6.3939 -1.8608  0.5826  1.9461  4.9661
##
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)              -5.20334   11.11810  -0.468    0.644
## pollution_df$wind        -0.42706    0.08645  -4.940 3.58e-05 ***
## pollution_df$temperature  0.52035    0.10813   4.812 5.05e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.95 on 27 degrees of freedom
## Multiple R-squared:  0.7773, Adjusted R-squared:  0.7608
## F-statistic: 47.12 on 2 and 27 DF,  p-value: 1.563e-09
```

oxidant = -5.2 - 0.4*wind + 0.5*temperature + error, with R-squared = 0.8.

```
summary(lm(pollution_df$oxidant~ pollution_df$wind + pollution_df$temperature + pollution_df$da
```

Step-down

```
##
## Call:
## lm(formula = pollution_df$oxidant ~ pollution_df$wind + pollution_df$temperature +
##     pollution_df$day + pollution_df$humidity + pollution_df$insolation)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -6.6920 -1.1675  0.2582  1.8289  4.0773
##
## Coefficients:
##                           Estimate Std. Error t value Pr(>|t|)
## (Intercept)              -12.04010   21.20961  -0.568  0.57553
## pollution_df$wind         -0.44749    0.09103  -4.916 5.14e-05 ***
## pollution_df$temperature   0.55714    0.15347   3.630  0.00133 **
## pollution_df$day          -0.02997    0.13995  -0.214  0.83227
## pollution_df$humidity      0.06818    0.13336   0.511  0.61384
## pollution_df$insolation    0.01822    0.05583   0.326  0.74694
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.977 on 24 degrees of freedom
## Multiple R-squared:  0.7984, Adjusted R-squared:  0.7564
## F-statistic: 19.01 on 5 and 24 DF,  p-value: 1.203e-07
```

Day has the largest p-value and the value is larger than 0.05. Removing it.

```
summary(lm(pollution_df$oxidant ~ pollution_df$wind + pollution_df$temperature + pollution_df$h
```

```
##
## Call:
## lm(formula = pollution_df$oxidant ~ pollution_df$wind + pollution_df$temperature +
##     pollution_df$humidity + pollution_df$insolation)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -6.5861 -1.0961  0.3512  1.7570  4.0712
##
## Coefficients:
##                           Estimate Std. Error t value Pr(>|t|)
## (Intercept)              -15.49370   13.50647  -1.147  0.26219
## pollution_df$wind         -0.44291    0.08678  -5.104 2.85e-05 ***
## pollution_df$temperature   0.56933    0.13977   4.073  0.00041 ***
## pollution_df$humidity      0.09292    0.06535   1.422  0.16743
## pollution_df$insolation    0.02275    0.05067   0.449  0.65728
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.92 on 25 degrees of freedom
## Multiple R-squared:  0.798,  Adjusted R-squared:  0.7657
## F-statistic: 24.69 on 4 and 25 DF,  p-value: 2.279e-08
```

Insolation is the largers from the insignificant. Removing it.

```
summary(lm(pollution_df$oxidant~ pollution_df$wind + pollution_df$temperature + pollution_df$hu
```

```
##
## Call:
## lm(formula = pollution_df$oxidant ~ pollution_df$wind + pollution_df$temperature +
##     pollution_df$humidity)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -6.5887 -1.1686  0.1978  1.9004  4.1544
##
## Coefficients:
##                           Estimate Std. Error t value Pr(>|t|)
## (Intercept)              -16.60697   13.07154  -1.270    0.215
## pollution_df$wind         -0.44620    0.08513  -5.241 1.78e-05 ***
## pollution_df$temperature   0.60190    0.11764   5.117 2.47e-05 ***
## pollution_df$humidity      0.09850    0.06316   1.559    0.131
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.874 on 26 degrees of freedom
## Multiple R-squared:  0.7964, Adjusted R-squared:  0.7729
## F-statistic: 33.89 on 3 and 26 DF,  p-value: 3.904e-09
```

Humidity is the only insignificant. Removing.

```
summary(lm(pollution_df$oxidant~ pollution_df$wind + pollution_df$temperature))
```

```
##
## Call:
## lm(formula = pollution_df$oxidant ~ pollution_df$wind + pollution_df$temperature)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -6.3939 -1.8608  0.5826  1.9461  4.9661
##
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)              -5.20334   11.11810  -0.468    0.644
## pollution_df$wind        -0.42706    0.08645  -4.940 3.58e-05 ***
## pollution_df$temperature  0.52035    0.10813   4.812 5.05e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.95 on 27 degrees of freedom
## Multiple R-squared:  0.7773, Adjusted R-squared:  0.7608
## F-statistic: 47.12 on 2 and 27 DF,  p-value: 1.563e-09
```

All remaining variables are significant. Resulting model: oxidant = -5.2 - 0.4*wind + 0.5*temperature + error, with R-squared = 0.8. The model is the same as obtained with the step-up approach.

d) Determine 95% confidence and prediction intervals for oxidant using the model you preferred in c) for wind=33, temperature=54, humidity=77 and insolation=21.

```
x1 <- pollution_df$wind
x2 <- pollution_df$temperature

mod = lm(pollution_df$oxidant ~ x1 + x2)

newxdata = data.frame(x1=33, x2=54)

predict(mod, newxdata, interval='prediction', level=0.95)
```

```
##       fit        lwr      upr
## 1 8.80281 -0.5617877 18.16741
```

```
predict(mod, newxdata, interval='confidence', level=0.95)
```

```
##       fit      lwr      upr
## 1 8.80281 1.656548 15.94907
```