# Design and Analysis of Experiments: R Cheat-Sheet

## General symbols and commands in R:

| | |
|---|---|
| `<-` | assign |
| `~` | as a function |
| `$` | indicates a variable in a datafile, ex: `DataFile$VarName` |
| `#` | comment, ignores everything after the # signal |
| `str(DataFile)` | view file structure |
| `as.factor(VarName)` | create factors for the analysis of variance |
| `aov(…)` | performs analysis of variance |
| `lm(…)` | builds a regression model |
| `summary(object)` | shows the results stored in object |
| `plot(…)` | creates a plot |
| `abline(…)` | plots a straight line |
| `library(…)` | loads an R package |
| `contour(…)` | builds a contour plot from a linear model |

## Nomenclature:

| | |
|---|---|
| `DataFile` | name of the csv datafile |
| `Y` | response variable |
| `A, B, C, D` | natural variables |
| `xA, xB, xC, xD` | coded variables |
| `VarName, Var1, Var2` | any variable: `xA, xB, xC, xD, A, B, C, D` |
| `FactorName, FactorA, FactorB, Factor C, FactorD` | creates variables as factors |
| `aovObject` | object created to store the result of an analysis of variance (`aov`) |
| `lmObject` | object created to store the result of a linear model (`lm`) |

## Analysis of Variance (ANOVA):

```
DataFile$FactorName <- as.factor(DataFile$VarName)      # creates factor FactorName in a DataFile using a variable VarName

aovObject <- aov(Y ~ factor_list, data = DataFile)      # performs the analysis of variance
summary(aovObject)                                      # shows the results stored in aovObject
```

## Regression Model:

```
lmObject <- lm(Y ~ regression_variables, data=DataFile)     # builds the regression model
summary(lmObject)                                           # shows the results stored in lmObject
```

## Residuals Plot:

```
plot(DataFile$Y, lmObject$residuals,                        # creates a plot of the residuals vs experimental results
     xlab = "Experimental Results", ylab = "Residuals") +   # set the x and y axis titles
  abline(h=0, col = "gray75")                               # plots a horizontal line at y=0, gray colour
```

## Contour Plots:

```
library(rsm)                                                # loads the response surface methodology package

contour(lmObject, ~ Var1 + Var2,                            # creates a contour plot of the predicted response of the lmObject with variables Var1 and Var2
        image = TRUE,                                       # creates a colored image as background
        zlim = c(45,100),                                   # set the limits for the contour lines of the predicted response
        xlabs = c("VarName2 title", "VarName1 title"))      # set the axis titles
```

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Examples of `factor_list` syntax:

| `fator_list` | Returns the analysis of variance of: |
|---|---|
| `FactorA + FactorB` | Main factors A and B |
| `FactorA + FactorB + FactorA:FactorB` or `FactorA * FactorB` | Main factors A and B and two-factor interaction AB |
| `FactorA + FactorB + FactorC` | Main factors A, B and C |
| `(FactorA + FactorB + FactorC)^2` | Main factors A, B and C, and two-factor interactions AB, AC and BC |
| `FactorA * FactorB * FactorC` or `(FactorA + FactorB + FactorC)^3` | Main factors A, B and C, two-factor interactions AB, AC and BC, and three-factor interaction ABC |
| `FactorA + FactorB + FactorC + FactorD` | Main factors A, B, C and D |
| `(FactorA + FactorB + FactorC + FactorD)^2` | Main factors A, B, C and D, and two-factor interactions AB, AC, AD, BC, BD and CD |
| `(FactorA + FactorB + FactorC + FactorD)^3` | Main factors A, B, C and D, two-factor interactions AB, AC, AD, BC, BD and CD, and three-factor interactions ABC, ABD, ACD and BCD |
| `FactorA * FactorB * FactorC * FactorD` | Complete model: main factors, two-factor interactions, three-factor interactions and a four-factor interaction |

Examples of `regression_variables` syntax:

| `regression_variables` | Resulting regression model |
|---|---|
| `xA + xB` | $y = b_0 + b_A x_A + b_B x_B$ |
| `xA*xB` or `xA + xB + xA*xB` or `(xA + xB)^2` | $y = b_0 + b_A x_A + b_B x_B + b_{AB} x_A x_B$ |
| `xA*xB + xC` | $y = b_0 + b_A x_A + b_B x_B + b_C x_C + b_{AB} x_A x_B$ |
| `xA*xB + xA*xC + xB*xC` or `(xA + xB + xC)^2` | $y = b_0 + b_A x_A + b_B x_B + b_C x_C + b_{AB} x_A x_B + b_{AC} x_A x_C + b_{BC} x_B x_C$ |
| `xA*xB*xC` or `(xA + xB + xC)^3` | $y = b_0 + b_A x_A + b_B x_B + b_C x_C + b_{AB} x_A x_B + b_{AC} x_A x_C + b_{BC} x_B x_C + b_{ABC} x_A x_B x_C$ |

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