Completely Randomized Design

Introduction

Responses among experimental units vary due to many different causes, known and unknown. The process of the separation and comparison of sources of variation is called the Analysis of Variance (AOV).
The AOV can be used for this purpose. It involves:
1. The partitioning of the total sum of squares of the experiment into each specified source of variation.
2. The estimation of the variance per experimental unit from these sources of variation.
3. The comparison of these variances by F-tests, which will lead to conclusions concerning the equality of the means.
The completely randomized design (CRD) refers to the random assignment of experimental units to a set of treatments. It is essential to have more than one experimental unit per treatment to estimate the magnitude of experimental error and to make probability statements concerning treatment effects.

Analysis of variance of a CRD

Source	df	Sum of squares (SS)	Mean squares (MS)	Observed F
Total	kr - 1	TSS		
Between treatments	k - 1	SST	MST	MST/MSE
Within treatments (experimental error)	k(r - 1)	SSE	MSE	

where r is the replication number per treatment.

Procedure:

- Import the data set
- Determine the summary and ANOVA using R functions
- Visualize the problem using R functions

Problem:

A car rental agency, which uses 5 different brands of tyres in the process of deciding the brand of tyre to purchase as standard equipment for its fleet, finds that each of 5 tyres of each brand last the following number of kilometres (in thousands):

A	B	C	D	E
36	46	35	45	41
37	39	42	36	39
42	35	37	39	37
38	37	43	35	35
47	43	38	32	38

Test the hypothesis that the five brands have almost the same average life.

Code and Results:

```
#One-way ANOVA
# Types of tyres
A=c(36,37,42,38,47)
B=c(46,39,35,37,43)
C=c(35,42,37,43,38)
D=c(45,36,39,35,32)
E=c(41,39,37,35,38)
group<-data.frame(cbind(A,B,C,D,E))
group
```

```
##    A  B  C  D  E
## 1 36 46 35 45 41
## 2 37 39 42 36 39
## 3 42 35 37 39 37
## 4 38 37 43 35 35
## 5 47 43 38 32 38
```

```
summary(group)
```

```
##        A               B               C               D               E
##  Min.   :36   Min.   :35   Min.   :35   Min.   :32.0   Min.   :35
##  1st Qu.:37   1st Qu.:37   1st Qu.:37   1st Qu.:35.0   1st Qu.:37
##  Median :38   Median :39   Median :38   Median :36.0   Median :38
##  Mean   :40   Mean   :40   Mean   :39   Mean   :37.4   Mean   :38
##  3rd Qu.:42   3rd Qu.:43   3rd Qu.:42   3rd Qu.:39.0   3rd Qu.:39
##  Max.   :47   Max.   :46   Max.   :43   Max.   :45.0   Max.   :41
```

```
# stack vector from data frame
stgr<-stack(group);stgr
```

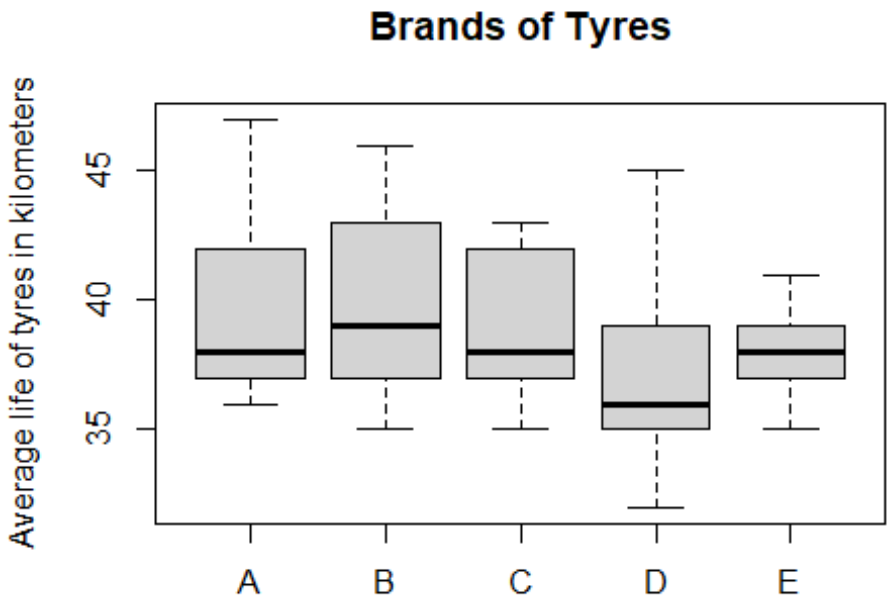
```
##    values ind
## 1      36   A
## 2      37   A
## 3      42   A
## 4      38   A
## 5      47   A
```

```
## 6      46   B
## 7      39   B
## 8      35   B
## 9      37   B
## 10     43   B
## 11     35   C
## 12     42   C
## 13     37   C
## 14     43   C
## 15     38   C
## 16     45   D
## 17     36   D
## 18     39   D
## 19     35   D
## 20     32   D
## 21     41   E
## 22     39   E
## 23     37   E
## 24     35   E
## 25     38   E
```

```
# completely randomized design
crd<-aov(values~ind,data=stgr)
# ANOVA table
summary(crd)
```

```
##             Df Sum Sq Mean Sq F value Pr(>F)
## ind          4   27.4    6.86   0.422  0.791
## Residuals   20  325.2   16.26
```

```
# Visualization of data
boxplot(group, ylab="Average life of tyres in kilometers",main="Brands of
Tyres")
```


Brands of Tyres
Average life of tyres in kilometers
35
40
45
A
B
C
D
E