

Example 1: One Way ANOVA in MINITAB

A consumer group wants to compare a new brand of wax (Brand-X) to two leading brands (Sureglow and Mirrorsheen) in terms of Effectiveness of wax. Following data is collected for this purpose:

Brand	Effectiveness	Brand	Effectiveness	Brand	Effectiveness
Sureglow	93	Mirrorsheen	90	Brand_X	105
Sureglow	96	Mirrorsheen	97	Brand_X	91
Sureglow	87	Mirrorsheen	91	Brand_X	95
Sureglow	91	Mirrorsheen	94	Brand_X	107
Sureglow	88	Mirrorsheen	100	Brand_X	90
Sureglow	85	Mirrorsheen	95	Brand_X	96
Sureglow	88	Mirrorsheen	88	Brand_X	92
Sureglow	91	Mirrorsheen	92	Brand_X	94
Sureglow	82	Mirrorsheen	94	Brand_X	84
Sureglow	91	Mirrorsheen	89	Brand_X	86
Sureglow	86	Mirrorsheen	96	Brand_X	82
Sureglow	93	Mirrorsheen	91	Brand_X	91
Sureglow	91	Mirrorsheen	97	Brand_X	106
Sureglow	87	Mirrorsheen	92	Brand_X	90
Sureglow	88	Mirrorsheen	92	Brand_X	91
				Brand_X	92
				Brand_X	91
				Brand_X	106
				Brand_X	98
				Brand_X	97
				Brand_X	80
				Brand_X	97
				Brand_X	91
				Brand_X	99
				Brand_X	86

To test the null hypothesis of equal mean effectiveness for the three brands of wax, the data is first converted to Group Format which will have 2 columns, Brand and Effectiveness.

ANOVA in R

```
d1<-read.csv("g:/Stats24x7/R/WaxEffectiveness.csv",header=TRUE)
```

```
attach(d1)
```

```
> names(d1)
[1] "Brand"      "Effectiveness"
```

```
> a1 <- aov(Effectiveness ~ Brand, data=d1)
```

```
> a1
Call:
aov(formula = Effectiveness ~ Brand, data = d1)
```

Terms:

```
      Brand Residuals
Sum of Squares 197.0085 1626.3733
Deg. of Freedom    2     52
```

```
Residual standard error: 5.592532
Estimated effects may be unbalanced
```

```
> summary(a1)
      Df Sum Sq Mean Sq F value Pr(>F)
Brand   2 197.01  98.504  3.1495 0.05116 .
Residuals 52 1626.37 31.276
```

```
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Read the datafile
WaxEffectiveness.csv in R.

Attach the dataframe d1.

Look at the variable names.

Run 1-way ANOVA in R.

Output of 1-way ANOVA in R.

Example 2: Two Way ANOVA in MINITAB

Following table shows drying time of concrete obtained from a set of 12 experiments conducted at 3 levels of CONCRETE amounts, and 2 levels of WATER amounts.

CONCRETE(CUPS)	WATER(CUPS)	TIME(MINUTES)
1.5	0.25	23
1.5	0.25	21
1.5	0.5	153
1.5	0.5	161
1.75	0.25	25
1.75	0.25	27
1.75	0.5	159
1.75	0.5	171
2	0.25	29
2	0.25	31
2	0.5	183
2	0.5	187

Test if the factors CONCRETE and WATER have an effect on mean drying time.

Open the data file Concrete.csv in R:

```
d2<-read.csv("g:/Stats24x7/R/Concrete.csv",header=TRUE)
attach(d2)
```

```
> names(d2)
[1] "CONCRETE" "WATER" "TIME"
```

Read the datafile
Concrete.csv in R.

Attach the dataframe d2.

Look at the variable names.

```
> a2 <- aov(TIME ~ CONCRETE + WATER, data=d2)
> a2
```

Run 2-way ANOVA in R, the
model here is ADDITIVE.

Call:

```
aov(formula = TIME ~ CONCRETE + WATER, data = d2)
```

OUTPUT:

Terms:

	CONCRETE	WATER	Residuals
Sum of Squares	648	61347	366
Deg. of Freedom	1	1	9

Residual standard error: 6.377042

Estimated effects may be unbalanced

ANOVA in R

```
> summary(a2)
      Df Sum Sq Mean Sq F value Pr(>F)
CONCRETE  1  648    648  15.934 0.003149 **
WATER     1 61347  61347 1508.533 2.471e-11 ***
Residuals  9   366    41
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

OUTPUT - continued:
Both terms CONCRETE and
WATER are significant.

```
> a2I <- aov(TIME ~ CONCRETE + WATER + CONCRETE * WATER , data=d2)
> a2I
Call:
aov(formula = TIME ~ CONCRETE + WATER + CONCRETE * WATER, data = d2)
```

Run 2-way
ANOVA in R, the
model here has
an INTERACTION
TERM.

```
Terms:
      CONCRETE WATER CONCRETE:WATER Residuals
Sum of Squares    648 61347         200    166
Deg. of Freedom    1  1         1      8
```

OUTPUT:
Both terms CONCRETE and
WATER are significant, and
the INTERACTION is also
significant.

```
Residual standard error: 4.555217
Estimated effects may be unbalanced
```

```
> summary(a2I)
      Df Sum Sq Mean Sq F value Pr(>F)
CONCRETE  1  648    648  31.2289 0.0005173 ***
WATER     1 61347  61347 2956.4819 1.452e-11 ***
CONCRETE:WATER 1  200    200  9.6386 0.0145640 *
Residuals  8   166    21
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

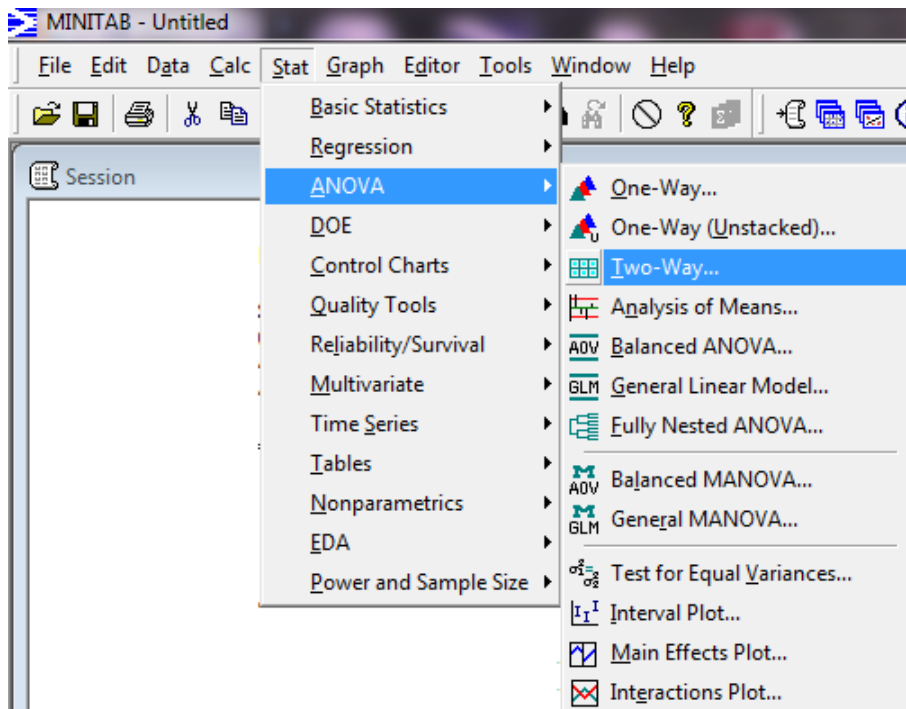


Figure 2b: Running Two-Way ANOVA in MINITAB

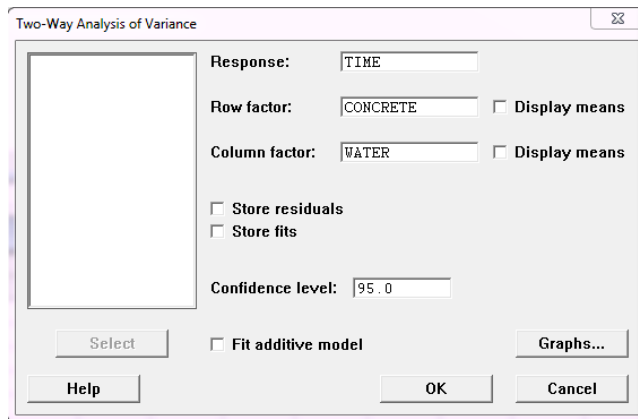


Figure 2b: Selecting Variables

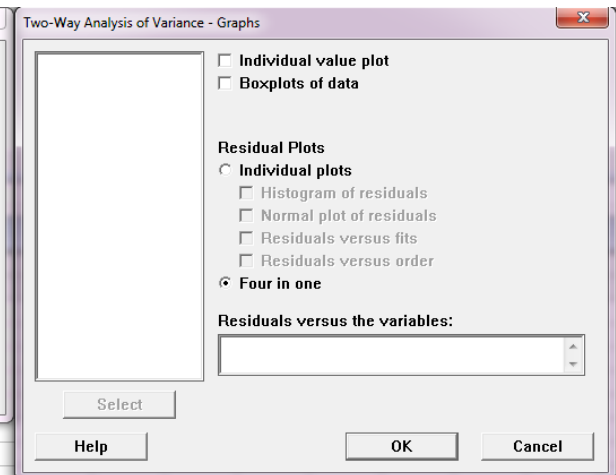


Figure 2b: Selecting Residual Plots

Output from MINITAB is shown below. The residual plots (Figure 2d) indicate that the residuals are normally distributed.

Two-way ANOVA: TIME versus CONCRETE, WATER

Source	DF	SS	MS	F	P
CONCRETE	2	672	336.0	17.08	0.003
WATER	1	61347	61347.0	3119.34	0.000
Interaction	2	224	112.0	5.69	0.041
Error	6	118	19.7		

CONCRETE significant
 WATER significant
 INTERACTION significant

ANOVA in R

Total 11 62361

S = 4.435 R-Sq = 99.81% R-Sq(adj) = 99.65%

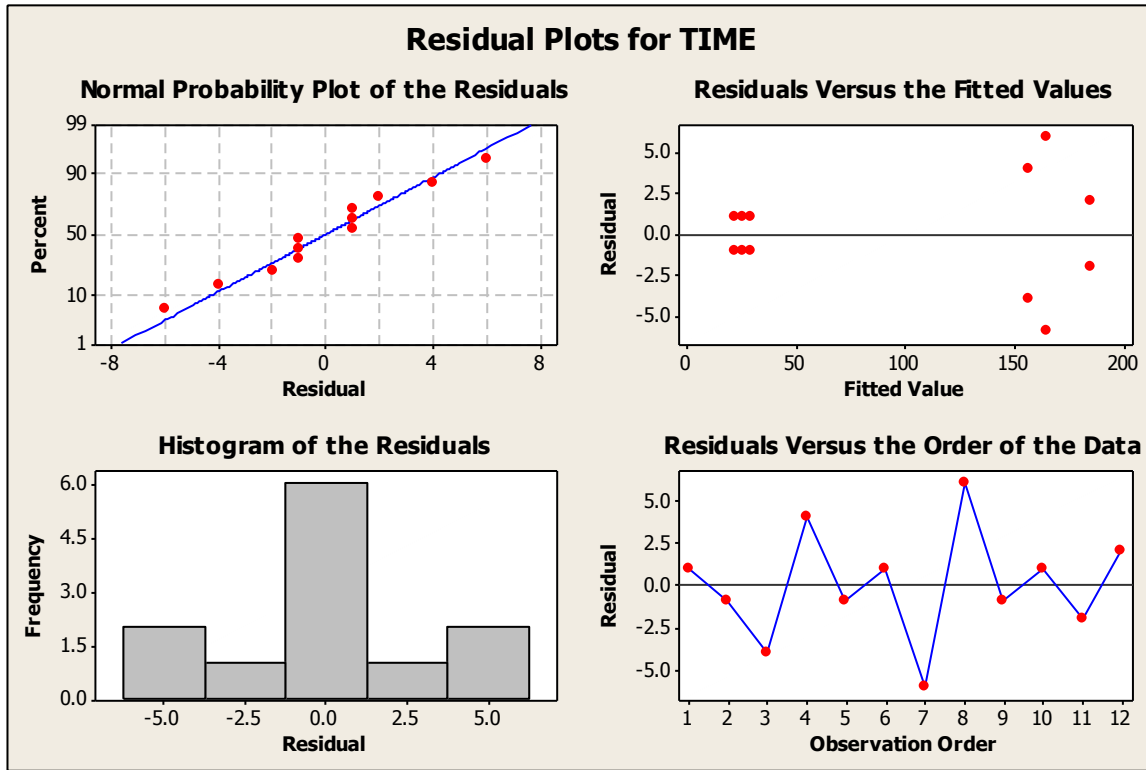


Figure 2d: Residual plots