Statistics Kingdom

ANOVA Calculator

One-Way ANOVA Calculator and Tukey HSD

Significance level (α): 0,05
Outliers: Included
Effect: Medium
Effect type: f
Effect Size: 0.25
Rounding: 4

- (•) Enter raw data directly
- ( ) Enter raw data from excel

Tutorial
ANOVA

Calculators

Kruskal-Wallis test
Two way ANOVA
Levene's test

Enter sample data directly

Groups:	Intern	Junior	Middle	Senior
Data:	6	2	5	4
	6	2	5	4
	6	2	5	4
	7	5	1	3
	7	5	1	3
	7	5	1	3
	7	7	7	5
	7	7	7	5
	7	7	7	5
	7	1	7	1
	7	1	7	1
	7	1	7	1
	7	6	6	6
	7	6	6	6
	7	6	6	6
Skewness:	-1.955761	-0.131503	-0.697681	-1.446115
Excess kurtosis:	2.04	-1.591132	-1.024233	0.670582
Normality	3.487e-7	0.000006418	0.00003043	4.341e-10
Outliers	6, 6, 6			1, 1, 1
Mean	6.83333	4.35294	5.09091	5.83333
S	0.38348	2.37338	2.18466	1.94014

Calculate | Validate | Insert column | Delete column | Clear | Load last run

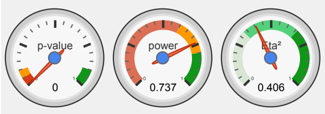
Header: You may change groups' names to the real names.
Data: When entering data, press Enter or , (comma) after each value.
You may paste full column from excel.
The calculator ignores empty cells or non-numeric cells.

Group1 contains 18 values
Group2 contains 51 values
Group3 contains 33 values
Group4 contains 54 values
validation:success

Hover over the cells for more information.

Source	DF	Sum of Square	Mean Square	F Statistic	P-value
Groups (between groups)	3	104.8564	34.9521	8.3484	0.00003566
Error (within groups)	152	636.3743	4.1867		
Total	155	741.2308	4.7821		

R code.



One Way ANOVA test, using F distribution df(3,152) (right tailed)

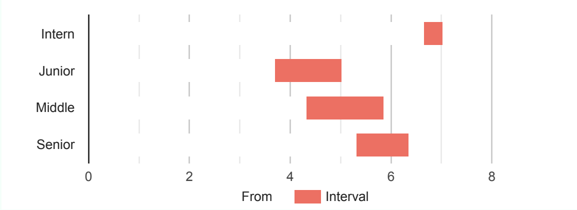
1. H_0 hypothesis
Since p-value<α, H_0 is rejected.
Some of the groups' averages consider to be not equal.
In other words, the difference between the averages of some groups is big enough to be statistically significant.

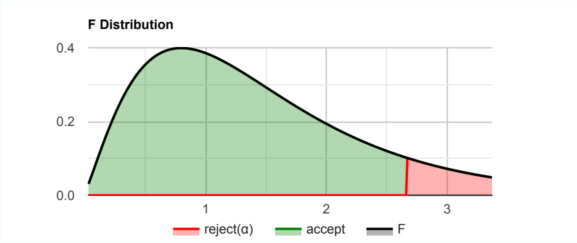
2. P-value
p-value equals **0.0000356636**, [p(x ≤ F) = 0.999964]. It means that the chance of type1 error (rejecting a correct H_0) is small: 0.00003566 (0.0036%)
The smaller the p-value the stronger it support H_1

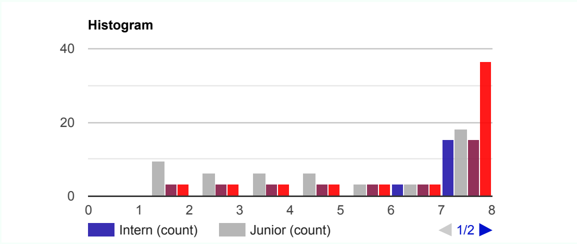
3. The statistics
The test statistic F equals **8.348428**, which is not in the 95% region of acceptance: [-∞ : 2.6641]

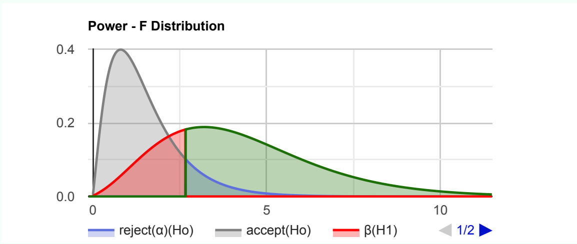
4. Effect size
The observed effect size f is large (0.41). That indicates that the magnitude of the difference between the averages is large.
The η^2 equals 0.14. It means that the **group** explains 14.1% of the variance from the average (similar to R^2 in the linear regression)

5. Tukey HSD / Tukey Kramer
The means of the following pairs are significantly different: **x1-x2, x1-x3, x2-x4**.









Validation

Test power

Although the priori power is medium (0.7372), the H_0 is rejected.

Equality of variances

The tool used the Levene's test to assess the equality of variances.
The population's variances consider to be **not equal**. (p-value = 0.0000114).
Levene's test power consider to be medium (0.74).
The groups' size consider different. (The ratio between the bigger group and the smaller group is: 3)

It is suggested to consider the **Kruskal-Wallis ANOVA.** non-parametric test.

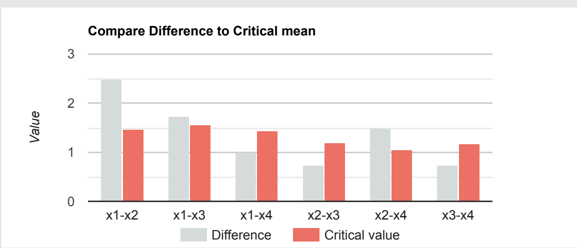
Normality assumption

The assumption was checked based on the Shapiro-Wilk Test. (α=0.05)
The ANOVA test is considered robust for moderate violation of the normality assumption.
From the groups with small sample size, less than 30, **1** group doesn't distribute normally (p-value is 3.49e-7).
You should consider transform the data or use the Kruskal–Wallis non-parametric test.

Tukey HSD / Tukey Kramer

Pair	Difference	SE	Q	Lower CI	Upper CI	Critical Mean	p-value
x1-x2	2.4804	0.3967	6.2531	1.0232	3.9376	1.4572	0.0001085
x1-x3	1.7424	0.4239	4.11	0.185	3.2999	1.5574	0.02165
x1-x4	1	0.3938	2.5395	-0.4466	2.4466	1.4466	0.2794
x2-x3	0.738	0.3232	2.2831	-0.4495	1.9254	1.1875	0.3736
x2-x4	1.4804	0.2825	5.2402	0.4425	2.5182	1.0378	0.001664
x3-x4	0.7424	0.3197	2.3223	-0.432	1.9169	1.1744	0.3582

Group	x2	x3	x4
x1	2.48	1.74	1
x2	0	0.74	1.48
x3	0.74	0	0.74



ANOVA

What is the ANOVA?

The ANOVA test checks if the difference between the averages of two or more groups is significant, using sample data.
ANOVA is usually used when there are at least three groups since for two groups, the *two-tailed* pooled variance t-test and the *right-tailed* ANOVA test have the same result.
The basic ANOVA test contains only one categorical value, one-way ANOVA. For example, if you compare the performence of three schools, the categorical variable is school, and the possible values of the categorical variable are School-A, School-B, School-C. There are more complex ANOVA tests that contain two categorical variables (Two-way ANOVA calculator), or more. When performing a one-way ANOVA test, we try to determine if the difference between the averages reflects a real difference between the groups, or is due to the random noise inside each group.
The F statistic represents the ratio of the variance between the groups and the variance inside the groups. Unlike many other statistic tests, the smaller the F statistic the more likely the averages are equal.

Example: Compare four fertilizers used in four fields
H_0: The average weight of crops per square meter is equal in all fields.
H_1: At least one field yields a different average per square meter.

Right-tailed, for ANOVA test you can use only the right tail. Why?

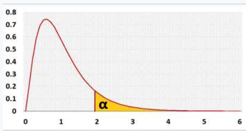
Hypotheses

H_0: $\mu_1 = ... = \mu_k$
H_1: not($\mu_1 = ... = \mu_k$)

ANOVA formula

$$F = \frac{MSG}{MSE}$$

F distribution



Assumptions

- Independent samples
- Normal distribution of the analyzed population
- Equal standard deviation, $\sigma_1=\sigma_2=...=\sigma_k$
  The assumption is more important when the groups' sizes not similar

Required Sample Data

- Sample data from all compared groups

Parameters

- **k** - Number of groups.
- **n_i** - Sample side of group i
- **n** - Overall sample side, includes all the groups (Σn_i, i=1 to k)
- **$\bar{x}_i$** - Average of group i.
- **$\bar{x}$** - Overall average ($\Sigma x_{i,j}$ / n, i=1 to k, j=1 to n_i)
- **S_i** - Standard deviation of group i

Results calculations

Source	Degrees of Freedom	Sum of Squares	Mean Square	F statistic	p-value
Groups (between groups)	k - 1	$SSG=\sum_{i=1}^{k} n_i\,(\bar{x}_i-\bar{x})^2$	MSG = SSG / (k - 1)	F = MSG / MSE	P(x > F)
Error (within groups)	n - k	$SSE=\sum_{i=1}^{k}(n_i-1)\,S_i^2$	MSE = SSE / (n - k)		
Total	n - 1	SS(total) = SSG + SSE	Sample Variance = SS(total) / (n - 1)		

R Code

The following R code should produce the same results

```
value0 <-
c(6,6,6,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,1,1,1,1,1,1,1,1,2,2,2,2,2,2,3,3,3,3,3,3,4,4,4,4,4,4,5,5,5,6,6,6,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,1,1,1,2,2,2,3,3,3,4,4,4,5,5,5,6,6,6,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,1,1,1,2,2,2,3,3,3,4,4,4,5,5,5,6,6,6,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,7,
value <- c(value0)
group1 <- c(rep("Intern", 18), rep("Junior", 51), rep("Middle", 33), rep("Senior", 54))
my.dataframe<-data.frame(value, group1)
res.aov <- aov(value ~ group1, data = my.dataframe)
summary(res.aov)
TukeyHSD(res.aov)
```