Example of One WAY AOV
with multiple comparisons 11/14/06


```
data t17_2;
input y brand num;
cards;
  43.9  1   1
  39.0  1   2
  46.7  1   3
  43.8  1   4
  44.2  1   5
  47.7  1   6
  43.6  1   7
  89.8  2   1
  87.1  2   2
  92.7  2   3
  90.6  2   4
  87.7  2   5
  92.4  2   6
  86.1  2   7
  68.4  3   1
  69.3  3   2
  68.5  3   3
  66.4  3   4
  70.0  3   5
  68.1  3   6
  70.6  3   7
  36.2  4   1
  45.2  4   2
  40.7  4   3
  40.5  4   4
  39.3  4   5
  40.3  4   6
  43.2  4   7
  ;run;

Proc anova data=t17_2;
class brand;
model y=brand/;
means brand / tukey;
means brand / bon;
means brand/cldiff tukey;
run; quit;
```

data set name

y brand num

The data to be analyzed

does Tukey method on means (book method)

Another mult comparison method (not in our book)

CI interval approach to Tukey's method

The ANOVA Procedure

Class Level Information

Class	Levels	Values
brand	4	1 2 3 4

Number of Observations Read	28
Number of Observations Used	28

Dependent Variable: y

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	10956.86000	3652.28667	596.64	<.0001
Error	24	146.91429	6.12143		
Corrected Total	27	11103.77429			

R-Square	Coeff Var	Root MSE	y Mean
0.986769	4.070285	2.474152	60.78571

$H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4$

H_a: Not H_0

Reject H_0

Conclude: Evid to suggest at least one mean is diff than others

Tukey's Studentized Range (HSD) Test for y

NOTE: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	24
Error Mean Square	6.121429
Critical Value of Studentized Range	3.90126
Minimum Significant Difference	3.6482

$q_{.05}(4, 24)$ Table p9 708

$w = [q_{.05}(4,24)]\left[\frac{s}{\sqrt{n_t}}\right]$

$= [3.9]\frac{2.474152}{\sqrt{7}}$

≈ 3.6482

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	brand
A	89.486	7	2
B	68.757	7	3
C	44.129	7	1
C			
C	40.771	7	4

20.729

24.629

3.357

27.986

45.357

48.714

Notice these are ranked low to high bottom to top

The only difference in means that is less than $w = 3.6482$

The ANOVA Procedure
Bonferroni (Dunn) t Tests for y

NOTE: This test controls the Type I experimentwise error rate, but it generally has a higher

Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	24
Error Mean Square	6.121429
Critical Value of t	2.87509
Minimum Significant Difference	3.8023

A more conservative multiple comparison procedure compared to Tukey's

Means with the same letter are not significantly different.

Bon Grouping	Mean	N	brand
A	89.486	7	2
B	68.757	7	3
C	44.129	7	1
C			
C	40.771	7	4

To be declared significantly different the distance between means must 3.8023 or more.... which is more 'difficult' than the 3.6482 value needed for Tukey's

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The ANOVA Procedure

Tukey's Studentized Range (HSD) Test for y

Tukey's procedure but the entire set of 6 95% Familywise intervals is calculated (6 in one order and 6 in the other... whichever way you choose)

NOTE: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	24
Error Mean Square	6.121429
Critical Value of Studentized Range	3.90126
Minimum Significant Difference	3.6482

Comparisons significant at the 0.05 level are indicated by ***.

brand Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
2 - 3	20.729	17.080	24.377	***
2 - 1	45.357	41.709	49.005	***
2 - 4	48.714	45.066	52.363	***
3 - 2	-20.729	-24.377	-17.080	***
3 - 1	24.629	20.980	28.277	***
3 - 4	27.986	24.337	31.634	***
1 - 2	-45.357	-49.005	-41.709	***
1 - 3	-24.629	-28.277	-20.980	***
1 - 4	3.357	-0.291	7.005	
4 - 2	-48.714	-52.363	-45.066	***
4 - 3	-27.986	-31.634	-24.337	***
4 - 1	-3.357	-7.005	0.291	

$\pm$ 3.6482

$\pm$ 3.6482

CIs with 0 in the interval are not significant. Those CIs without 0 are considered significant

Notice how these 'agree'

```
data p11_36;
input mpg auto  $ brand $;
cards;
15.7 1 a
17.0 2 a
17.3 3 a
16.1 4 a

17.2 1 b
18.1 2 b
17.9 3 b
17.7 4 b

16.1 1 c
17.5 2 c
16.8 3 c
17.8 4 c
;run;

Proc anova data=p11_36;
class auto brand;
model mpg=auto brand/;
means brand/cldiff tukey;
run; quit;
```

The ANOVA Procedure

Dependent Variable: mpg

Source	DF	Anova SS	Mean Square	F Value	Pr > F
auto	3	2.52000000	0.84000000	3.75	0.0792
brand	2	2.89500000	1.44750000	6.46	0.0319
Error	6	1.34500000	0.22416667		
Corrected Total	11	6.76000000			

R-Square	Coeff Var	Root MSE	mpg Mean
0.801036	2.768786	0.473462	17.10000

Auto line tests hypothesis:

$H_0: \mu_{Auto\,1} = \mu_{Auto\,2} = \mu_{Auto\,3} = \mu_{Auto\,4}$

Brand line tests:

$H_0: \mu_A = \mu_B = \mu_C$ (Hyp of most interest)

The ANOVA Procedure

Tukey's Studentized Range (HSD) Test for mpg

NOTE: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	6
Error Mean Square	0.224167
Critical Value of Studentized Range	4.33902
Minimum Significant Difference	1.0272

Comparisons significant at the 0.05 level are indicated by ***.

brand Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
b - c	0.6750	-0.3522	1.7022	
b - a	1.2000	0.1728	2.2272	***
c - b	-0.6750	-1.7022	0.3522	
c - a	0.5250	-0.5022	1.5522	
a - b	-1.2000	-2.2272	-0.1728	***
a - c	-0.5250	-1.5522	0.5022	

A & B are diff

The ANOVA Procedure

Tukey's Studentized Range (HSD) Test for mpg

NOTE: This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than REGWQ.

Alpha	0.05
Error Degrees of Freedom	6
Error Mean Square	0.224167
Critical Value of Studentized Range	4.33902
Minimum Significant Difference	1.0272

Means with the same letter are not significantly different.

Tukey Grouping		Mean	N	brand
	A	17.7250	4	b
	A			
B	A	17.0500	4	c
B				
B		16.5250	4	a

Brand B & C not diff

Brand A & C not diff

B & A ARE diff