ECE 341 - Homework #15

F-Test and ANOVA. Due Friday, June 12th

Please make the subject "ECE 341 HW#15" if submitting homework electronically to Jacob_Glower@yahoo.com (or on blackboard)

Test of a 3+ Populations

1) The temperature drop of 3 different mugs over 15 minutes when filled with boiling water is measured

- A: Mean = 2.43 Standard Deviation = 0.0155, Na = 3 (sample size)
- B: Mean = 2.50 Standard Deviation = 0.06557, Nb = 3 (sample size)
- C: Mean = 2.73 Standard Deviation = 0.08145, Nc = 3 (sample size)

Determine if the means are the same using an ANOVA test.

Determine the global mean

$$\overline{G} = \left(\frac{1}{N}\right)\left(n_a\overline{A} + n_b\overline{B} + n_c\overline{C}\right)$$

$$\overline{G} = 2.5533$$

Determine MSSb and MSSw

MSSb:

$$MSS_b = \left(\frac{1}{k-1}\right)\left(n_a\left(\overline{A} - \overline{G}\right)^2 + n_b\left(\overline{B} - \overline{G}\right)^2 + n_c\left(\overline{C} - \overline{G}\right)^2\right)$$

$$MSS_w = \left(\frac{1}{N-k}\right)\left((n_a - 1)s_a^2 + (n_b - 1)s_b^2 + (n_c - 1)s_c^2\right)$$

```
Xa = 2.43;
Sa = 0.0155;
Xb = 2.50;
Sb = 0.06557;
Xc = 2.73;
Sc = 0.0815;
Na = 3;
Nb = 3;
Nc = 3;
k = 3;
N = Na + Nb + Nc

N =    9

G = (Na*Xa + Nb*Xb + Nc*Xc) / N

G =    2.5533

MSSb = (Na*(Xa-G)^2 + Nb*(Xb-G)^2 + Nc*(Xc-G)^2) / (k-1)
MSSb =    0.0739

MSSw = ((Na-1)*Sa^2 + (Nb-1)*Sb^2 + (Nc-1)*Sc^2) / (N-k)
MSSw =    0.0037

F = MSSb / MSSw
F =   19.8266
```

You can also get the same answer with an ANOVA table

A	B	C	A	B	C
			0.0155 std(A)	0.06557 std(B)	0.08145 std(C)
Na = 3	Nb = 3	Nc = 3	0.0004805 sum of squares	0.0086 sum of squares	0.0133 sum of squres
N = 9			0.0223 sum of squares		
2.43 mean(A)	2.50 mean(B)	2.73 mean(C)	MSSw = 0.0037		
2.5533 G = global mean					
0.0456 Na (A - G)^2	0.0085 Nb (B - G)^2	0.0936 Nc (C - G)^2			
0.1478 sum of squres					
MSSb = 0.0739					

Now use an F table with

- numerator = 2 degrees of freedom (k-1)
- denominator = 6 degrees of freedom (N-k)

This corresponds to a probability of 99.8%

I am 99.8% certain that the three data sets have a different mean

You'd have to do 1 on 1 t-tests to determine which one (or more) is the outlier.

- Enter values for degrees of freedom.
- Enter a value for one, and only one, of the remaining text boxes.
- Click the **Calculate** button to compute a value for the blank text box.

Degrees of freedom (v_1)	2
Degrees of freedom (v_2)	6
Cumulative prob: P(F ≤ 19.8266)	0.998
f value	19.8266

2) The height three people can jump is recorded (units = meters)

```
A:  0.413, 0.370, 0.345, 0.328, 0.424, 0.276, 0.494, 0.306, 0.419, 0.405
B:  0.390, 0.411, 0.543, 0.370, 0.425, 0.387, 0.556, 0.557, 0.603, 0.497
C:  0.649, 0.605, 0.628, 0.603, 0.645, 0.593, 0.637, 0.687, 0.635, 0.687
```

Determine if the means are the same using an ANOVA test.

```
A = [0.413, 0.370, 0.345, 0.328, 0.424, 0.276, 0.494, 0.306, 0.419, 0.405];
B = [0.390, 0.411, 0.543, 0.370, 0.425, 0.387, 0.556, 0.557, 0.603, 0.497];
C = [0.649, 0.605, 0.628, 0.603, 0.645, 0.593, 0.637, 0.687, 0.635, 0.687];

Xa = mean(A)

Xa =    0.3780

Xb = mean(B)

Xb =    0.4739

Xc = mean(C)

Xc =    0.6369

Na = length(A);
Nb = length(B);
Nc = length(C);
G = mean([A;B;C])

G = mean([A,B,C])

G =    0.4963

k = 3;
N = Na + Nb + Nc

N =   30

MSSb = (Na*(Xa-G)^2 + Nb*(Xb-G)^2 + Nc*(Xc-G)^2) / (k-1)

MSSb =    0.1713

MSSw = ((Na-1)*var(A) + (Nb-1)*var(B) + (Nc-1)*var(C)) / (N-k)

MSSw =    0.0043

F = MSSb / MSSw

F =   40.1502
```

From StatTrek, this corresponds to a probabilit of 0.9999999

I am 99.9999% certain that the three population means are not the same

Repeat with an ANOVA table

A	B	C	(A - mean(A))^2	(B - mean(B))^2	(C - mean(C))^2
0.413	0.39	0.649	0.0012	0.0070	0.0001
0.37	0.411	0.605	0.0001	0.0040	0.0010
0.345	0.543	0.628	0.0011	0.0048	0.0001
0.328	0.37	0.603	0.0025	0.0108	0.0011
0.424	0.425	0.645	0.0021	0.0024	0.0001
0.276	0.387	0.593	0.0104	0.0076	0.0019
0.494	0.556	0.637	0.0135	0.0067	0.0000
0.306	0.557	0.687	0.0052	0.0069	0.0025
0.419	0.603	0.635	0.0017	0.0167	0.0000
0.405	0.497	0.687	0.0007	0.0005	0.0025
Na = 10	Nb = 10	Nc = 10	SSa = 0.0384	SSb = 0.0674	SSc = 0.0094
N = 30			SSw = 0.1152 Sum of squares		
0.3780 mean(A)	0.4739 mean(B)	0.6369 mean(C)	MSSw = 0.0043		
0.4963 G = global mean					
0.1399 Na (A - G)^2	0.0050 Nb (B - G)^2	0.1978 Nc (C - G)^2			
0.3426 sum of squres					
MSSb = 0.1713					

- Enter values for degrees of freedom.
- Enter a value for one, and only one, of the remaining text boxes.
- Click the **Calculate** button to compute a value for the blank text box.

Degrees of freedom (v_1)	2
Degrees of freedom (v_2)	27
Cumulative prob: P(F ≤ 40.15)	0.999999991865805
f value	40.15

The reflex time of a person before and after drinking 2 shots is measured

Trial	Person A		Person B		Person C	
	sober	2 drinks	sober	2 drinks	sober	2 drinks
#1	0.2253	0.2559	0.1924	0.2721	0.2419	0.3012
#2	0.1923	0.3488	0.1893	0.2197	0.1976	0.2556
#3	0.1854	0.244	0.2081	0.2438	0.3063	0.2451

3) Determine if the means are the same for all six populations: Persons A, B, and C, sober and after 2 drinks.

Sober

```
% Sober
A = [0.2253, 0.1923, 0.1854];
B = [0.1924, 0.1893, 0.2081];
C = [0.2419, 0.1976, 0.3063];
% 2 drinks
D = [0.2559, 0.3488, 0.2440];
E = [0.2721, 0.2197, 0.2438];
F = [0.3012, 0.2556, 0.2451];


Na = length(A);
Nb = length(B);
Nc = length(C);
Nd = length(D);
Ne = length(E);
Nf = length(F);
Xa = mean(A);
Xb = mean(B);
Xc = mean(C);
Xd = mean(D);
Xe = mean(E);
Xf = mean(F);
Na = length(A);
Nb = length(B);
Nc = length(C);
Nd = length(D);
Ne = length(E);
Nf = length(F);
G = mean([A,B,C,D,E,F])
k = 6;
N = Na + Nb + Nc + Nd + Ne + Nf

MSSb = ( Na*(Xa-G)^2 + Nb*(Xb-G)^2 + Nc*(Xc-G)^2 + Nd*(Xd-G)^2 + Ne*(Xe-G)^2 +
Nf*(Xf-G)^2 ) / (k-1)

MSSw = ( (Na-1)*var(A) + (Nb-1)*var(B) + (Nc-1)*var(C) +  (Nd-1)*var(D) +
(Ne-1)*var(E) + (Nf-1)*var(F)) / (N-k)

F = MSSb / MSSw

G    =    0.2403
N    =    18
MSSb =    0.0037
MSSw =    0.0014
F    =    2.6061
```

From StatTrek, this F-score corresponds to a probability of 92%

- **I am 92% certain that the three groups do not have the same mean**
- **You should not combine all six groups: at least one has a diferent mean.**

My bet is there is a difference between sober and 2 drinks.