UNIVERSITI TEKNOLOGI MALAYSIA
SEMESTER II, SESSION 2014/2015
SSCE/SSE 2193: ENGINEERING STATISTICS

Chapter 6 Exercises

1. It was known that a toxic material was dumped in a river leading into a large salt-water commercial fishing area. Civil engineers studied the way the water carried the toxic material by measuring the amount of the material (in parts per million) found in oysters harvested at three different locations, ranging from the estuary out into the bay where the majority of commercial fishing was carried out. The resulting data are given below:

Location		
Site 1	Site 2	Site 3
15	19	22
26	15	26
20	10	24
20	26	26
29	11	15
28	20	17
21	13	24
26	15	
	18	

   Test whether there is a significant difference in the average parts per million of toxic material found in oysters harvested at three sites. Use $\alpha = 0.05$.

2. A quality control engineer conducted an experiment to investigate the effect of experience on an assembly line in terms of the average time required to complete an assembly task. If experience is found to be a factor, a training program is planned for new employees. The engineer randomly selected eight employees from groups who had completed 1, 2, 3, and 4 years of work experiences, respectively. The resulting data are given below:

Experience			
1	2	3	4
40.3	34.2	26.3	26.6
25.4	25.4	29.2	21.2
28.2	30.2	24.6	23.2
41.6	28.9	29.1	27.0
28.8	39.2	34.8	27.1
38.7	29.5	32.3	27.3
29.4	29.0	36.0	34.2
37.7	25.6	25.6	33.3

   (a) Test for any significant differences among years of experience for average assembly time. Use $\alpha = 0.05$

   (b) Do the data suggest that a training program might be productive?

3. The OPEC oil embargo made it evident that fuel economy in automobiles needed to be improved. Newer lightweight materials were sought for use in automobile engines. Comparisons on the density (in g/cm^3) were made among test material samples of steel, aluminium, and phenolic thermoset composites containing glass fibres, resulting in the following data:

	Materials	
Steel	Aluminium	Phenolics
7.60	2.90	1.79
7.81	2.67	1.72
7.72	2.80	1.67
7.68	2.85	1.80
7.79	2.60	1.50
7.76	2.76	1.63

Using an analysis of variance, state the correct hypothesis for testing equality of means in density for the three materials and conduct the ANOVA test. State your conclusion.. Use $\alpha = 0.01$ level of significance.

4. Consider the following set of dissolved oxygen concentration data obtained in 4 different seasons.

Season 1	5.62	6.12	6.62	6.21	7.08	5.36
Season 2	7.70	8.31	8.80	8.24	7.87	7.44
Season 3	2.52	5.44	4.94	2.99	4.39	4.44
Season 4	6.77	6.65	6.01	6.26	7.09	6.05

Use a one-way ANOVA to determine if season has a significant impact on oxygen variability at 0.05 level of significance.

5. Four different machines are used in manufacturing rubber seals. The machine are being compared with respect to tensile strength of the product. A random sample of seals from each machine is used to determine whether the mean tensile strength varies from machine to machine. The following data are the tensile strength measurements in kilograms per square centimeter x 10^{-1}.

Machine	1	17.5	16.4	20.3	14.6		
	2	19.2	16.8	18.5	21.4	21.5	20.1
	3	15.8	20.9	17.1	16.4	16.9	
	4	18.6	18.9	20.5	19.5	18.1	

Perform the analysis of variance at the 0.025 level of significance and indicate whether or not the mean tensile strengths differ significantly for the four machines.

6. In a biological experiment, 4 concentrations of a certain chemical are used to enhance the growth in centimeters of a certain type of plant over time. The growth of plants are measured. The following output are from Excel.

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Column 1	6	43.5	7.25	0.635		
Column 2	5	34.6	6.92	2.327		
Column 3	4	30.4	7.6	1.073333		
Column 4	6	49.7	8.283333	0.453667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5.755333	3	1.918444	1.814754	0.182699	5.185
Within Groups	17.97133	17	1.057137			
Total	23.72667	20				

(a) How many plants are used for each concentration?

(b) Can we conclude at $\alpha = 0.05$ level of significance that different concentrations affect the growth of the plant?

7. A company is considering four brands of lightbulbs to choose from. Before the company decides which lightbulbs to buy, they want to investigate if the mean lifetimes of the four types of lightbulbs are the same. The company's research department randomly selected a few bulbs of each brands and tested them. The following results are based on the number of hours (in thousands) that each of the bulbs lasted before being burned out. At 5% significance level, test the null hypothesis that the mean lifetime of bulbs for each of these four brands is the same.

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Column 1	8	187	23.375	7.982143		
Column 2	8	164	20.5	5.142857		
Column 3	8	197	24.625	5.410714		
Column 4	8	209	26.125	8.410714		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	136.5938	3	45.53125	6.758781	0.00143	2.946685
Within Groups	188.625	28	6.736607			
Total	325.2188	31				

Answers

1. $f_{calc} = 4.9471 > f_{0.05,2,21}(= 3.47)$; *A significant difference exists.*

2. (a) $f_{calc} = 2.603 > f_{0.05,3,28}(= 2.95)$; *No significant difference.*

    (b) *No*

3. $f_{calc} = 5982.001 > f_{0.01,2,15}(= 6.36)$; *Means are significantly different.*

4. $f_{calc} = 29.7986 > f_{0.05,3,20}(= 3.10)$; *Season has a significant impact on oxygen variability.*

5. $f_{calc} = 2.1656 < f_{0.025,3,16}(= 4.08)$; *The mean tensile strengths do not differ significantly.*

6. (a) $6, 5, 4$ *and* 6 *respectively.*

    (b) $P-value = 0.1827 > 0.05$; *Different concentrations do not affect the plant growth.*

7. $P-value = 0.00143 < 0.05$; *The mean lifetimes are significantly different.*