INSTITUTE OF TECHNOLOGY UNIVERSITY OF MORATUWA
COURSE : NDT Fourth Semester
Module : IS2402 Industrial Statistics and Modelling Computation
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Tutorial 6/Practical 6 – TWO FACTOR DESIGNS

1. Consider the data in Table Q.1 concerning the performance of an antenna aimed at a specific satellite. Management wishes to study the impact of two factors and their interaction: one factor is the type of mount of the antenna and the other is the temperature at which it operates. The dependent variable is a measure of the distortion of the transmission. Three antennae are tested at each combination of mount type and temperature. Test for differences among temperatures and mount types, and for the existence of interaction between temperature and mount type. Use α =0 .05.
2. Assume a fixed model.

   Table Q.1: Antenna performance

	Temperature		
Mount type	1	2	3
I	.80	1.10	.50
	1.00	1.15	.70
	1.05	1.20	.75
II	.60	.65	.55
	.80	.65	.90
	1.30	1.25	.95

   a. Identify the dependent variable, independent variables (factors), number of factor levels, number of replicates and number of data points.
   b. Find sums of squares, TSS, SSB_r, SSB_c , $SSI_{r,c}$, SSW and respective degree of freedoms.
   c. Perform two factor ANOVA using α = .05.
   d. Conduct relevant two-factor ANOVA in EXCEL.

3. This exercise is designed partly to illustrate that we often can't tell what is going on just by looking at the data. Table Q.2 contains two sets of data – each has the same row means, column means, row SSQ, column SSQ, degrees of freedom, and about the same range of numbers.

   Table Q.2: Two sets of data

Set 1						Set 2					
	Column factor						Columm factor				
Rows	a	b	c	d	e	Rows	a	b	c	d	e
I	35	39	37	43	41	I	27	53	23	53	39
II	43	45	33	57	47	II	39	51	37	43	55
III	39	51	35	59	51	III	45	45	49	39	57
IV	23	37	27	37	41	IV	21	23	31	45	45

(a) For each set of data, perform an ANOVA, with α = 0.05. The model is

$$Y_{ij} = \mu + \rho_i + \tau_j + \varepsilon_{ij}$$

(b) Why are the results so dramatically different from one set to the other?

4. The data in Table Q.3 concerns time before failure of a special-purpose battery. It is important in battery testing to consider different temperatures and modes of use; a battery that is superior at one temperature and mode of use is not necessarily superior at other treatment combinations. Furthermore, other factors may be relevant in addition to these two factors, depending on circumstances. In a battery-production situation, even for a specific battery size (such as AA), management is acutely aware of the trade-offs that need to be made in choosing the properties of the battery to be produced. In this study, the special-purpose batteries were being tested at four different temperatures, for three different modes of use (intermittent [I], continuous [C], sporadic [S]). There were two replicates at each of the 12 temperature, mode-of-use combinations. Test for differences due to temperature and mode of use, and for the existence of interaction between these factors. Assume a fixed model and use α = .05.

Q.3: Battery time before failure

	Temperature			
Mode of use	1	2	3	4
I	12, 16	15, 19	31, 39	53, 55
C	15, 19	17, 17	30, 34	51, 49
S	20, 21	19, 18	36, 37	54, 56

5. A process engineer is investigating the effect of machinery wear and cutting angle on the diameter of stainless-steel components. In his study, he tested two pieces of equipment (new and old) and three angles, and six components were produced per combination, as shown in Table Q.4 Test to see if the machinery wear or cutting angle affects the diameter of the components. Test for interaction as well.

Q.4: Diameter of stainless steel (in mm)

Equipment	Angle	1	2	3	4	5	6
New	1	169	173	178	172	172	170
New	2	180	190	189	184	182	188
New	3	210	208	199	204	208	200
Old	1	150	157	152	154	158	152
Old	2	160	162	158	162	155	160
Old	3	170	172	177	175	174	172