**IME 503- ANOVA LAB**

This is an important Lab dealing with the fundamental principles of ANOVA as discussed in class. Specifically, your team will be exposed to the following situations and analyses.

* Solving 1, 2, and 3-factor ANOVA models
* Conducting follow-up, multiple-comparison tests where applicable
* Comparison of two typical follow-up or multiple-comparison tests
* Computations and understanding of the interpretation for blocking extraneous sources of variability in ANOVA
* Computations and understanding of the interaction effect in Multi-factor DOE
* Computation of the replication effect in ANOVA
* Handling ANOVA computations and interpretations for the fixed effect, random effect and/or mixed effect DOE models
* Checking the validity of the assumptions for ANOVA models
* Conducting the analysis, both manually and by Minitab, where applicable

**Problem #1**

Tensile strength of five different synthetic fibers (with different Cotton %) have been measured and summarized in the following table.

**Tensile Strength (lb/in2)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **15%** | 7 | 7 | 15 | 11 | 9 |
| **20%** | 12 | 17 | 12 | 18 | 18 |
| **25%** | 14 | 18 | 18 | 19 | 19 |
| **30%** | 19 | 25 | 22 | 19 | 23 |
| **35%** | 7 | 10 | 11 | 15 | 11 |

1. Perform the ANOVA to see if there is a significant difference among the true means of tensile strength for these fibers. **Use manual and Minitab computations to verify your results.**
2. **Using Minitab,** perform both Tukey and Fisher multiple comparison tests. Comment on individual results as well as the observed differences between these two follow-up tests.
3. **Using Minitab,** check the validity of assumptions for this ANOVA model.

**Problem #2**

A Pharmaceutical company is conducting an experiment to determine the effectiveness of five different treatment substances on seven different patients. The following table includes the measurements (in appropriate units) for the outcome of the project.

**Treatment Substance**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Patients** | **1** | **2** | **3** | **4** | **6** |
| **1** | 8.6 | 8.1 | 8.5 | 8.6 | 8.7 |
| **2** | 10.3 | 10.0 | 9.9 | 10.6 | 10.2 |
| **3** | 12.4 | 11.8 | 12.3 | 12.5 | 12.2 |
| **4** | 9.7 | 9.8 | 9.9 | 10.4 | 10.4 |
| **5** | 8.6 | 8.4 | 9.7 | 9.9 | 9.5 |
| **6** | 9.3 | 9.6 | 10.3 | 10.5 | 10.2 |
| **7** | 11.1 | 10.6 | 11.6 | 10.9 | 11.4 |

1. Without blocking the patients, conduct an ANOVA model to see if the treatment substances are significantly different. Do the problem **manually** and then verify your solution on **Minitab**.
2. Perform the multiple comparison tests, using Tukey’s method (**Using Minitab**). Provide the relevant figures.
3. Block the patients and run an appropriate ANOVA model. Do the problem **manually and then verify your solution on Minitab.**
4. Make remarks about your findings in Part C, both numerical and practical.
5. Can you compute the Block X Treatment substance interaction? If yes, how? If no, why not?

**Problem #3**

The amount of rust (in appropriate units) on certain metal as a function of chemical type (1, 2, and 3) and application method (Dipping vs. Spraying) are tabulated in the following table.

|  |  |  |
| --- | --- | --- |
| **Chemical Type** | **Dipping Method** | **Spraying Method** |
| 1 | 4.0, 4.5, 4.3 | 5.4, 4.9, 5.6 |
| 2 | 5.6, 4.9, 5.4 | 5.8, 6.1, 6.3 |
| 3 | 3.8, 3.7, 4.0 | 5.5, 5.0, 5.0 |

1. Perform an appropriate analysis for this 3x2 ANOVAmodel, **both manual and by Minitab.**
2. State all your hypotheses and report your results.
3. Support your conclusion(s) with the appropriate plot(s) and comments? **Use Minitab’s main effects and interaction effects plots.**
4. **Using Minitab**, repeat Part a, however include replication as a source of variation. Report any differences on your significant sources of variability, if any.

**Problem # 4**

Data for a two-factor ANOVA model are presented in the following table. **Using Minitab,** perform the following analyses both for an **unrestricted and a restricted model**. Do not include the replication term.

|  |  |  |
| --- | --- | --- |
|  | **B1** | **B2** |
| **A1** | 24, 28, 21 | 67, 89, 70 |
| **A2** | 110, 90, 89 | 44, 48, 39 |

1. Conduct an appropriate ANOVA. Explain the results clearly. Plot both main effects and the interaction effect. Assume both factors are fixed effects.
2. Repeat Part A but with the assumption that both factors A and B are random effects.
3. Repeat Part A but with the assumption that we have a mixed-effect model, where A is a fixed-effect but B is a random-effect.
4. Repeat Part C except that A and B are switched in their status.

**Problem #5**

To test the effectiveness of three different detergents, the following data are collected as a function detergent brand (X, Y), washing temperature (Warm, Hot), and detergent form (Powder, Liquid). **Using Minitab**, conduct an appropriate analysis for this **23 ANOVA model** with eight combinations. Write all your hypotheses and make specific comments about your findings at p<0.05. Assume all factors are fixed effects. Conduct the ANOVA without and with the replication effect.

|  |  |
| --- | --- |
| **Treatment Combination** | **Replications (Appropriate units)** |
| X, W, P | 14.8, 15.0 |
| Y, W, P | 18.4, 18.8 |
| X, H, P | 17.8, 18.2 |
| X, W, L | 19.9, 20.3 |
| Y, H, P | 20.7, 21.1 |
| Y, W, L | 21.7, 21.9 |
| X, H, L | 22.6, 23.2 |
| Y, H, L | 23.4, 24.6 |

**Problem #6**

Consider the following set of independent random sample data from two different normal populations.

Sample 1 data: **10.8, 8.4, 6.0, 12.9, 7.7, and 6.5**

Sample 2 data: **13.5, 16.0, 9.6, 8.9, 14.6, and 11.0**

1. Test to see if the population means are significantly different at p< 0.03, by using both t-test and F-test. Comment on your findings. Do the analysis manually and then verify on Minitab.
2. Repeat Part A analysis with the assumption that the data collection is paired (repeated measurements, or blocked).