

STAT 2112: Computer Assignment #3

Note: For this assignment, assume that the level of significance, $\alpha = .05$. Answer only the questions which appear in this assignment.

1 Problem 1

1. **Question 1** Taken from McClave 12th edition problems 12.20 and 12.47. **Extracting water from oil.** In the oil industry, water that mixes with crude oil during production and transportation must be removed. Chemists have found that the oil can be extracted from the water and oil mixture electrically. Researchers at the University of Bergen located in Norway conducted a series of experiments to study the factors that influence the voltage, y , which is required to separate the water from the oil (*Journal of Colloid and Interface Science*, Aug. 1995). Out of seven variables which were investigated in the study, the five variables listed in Table 1 apply to this problem.

Table 1: Definitions of Variables

Variable	Name
y	Voltage
x_1	Volume
x_2	Salinity
x_3	Temperature
x_5	Surfactant

Each variable was measured at two levels: low and high. Sixteen water and oil mixtures were prepared using different combinations of the independent variables, then each emulsion was exposed to a high electric field. In addition, three mixtures were tested when all independent variables were set to 0. The set of data is called, H2OOIL.sav.

- (a)
- (b) (4 pts) Write the linear fixed effects model where y is the response variable and x_1 , x_2 , and x_5 are the explanatory variables. We will call this model the reduced model.
 - (c) (4 pts) Use SPSS to estimate the parameters of the model.
 - (d) (4 pts) Produce the ANOVA table.
 - (e) (4 pts) Produce a plot of residuals versus predicted values.
 - (f) (4 pts) Produce a QQ plot for residuals. (Remember that in SPSS we want the Normal P-P plot.)
 - (g) (4 pts) Is the model a good model? Let us assume that the theory is valid.
 - (h) (4 pts) Write the linear fixed effects model where y is the response variable and x_1 , x_2 , and x_5 are the explanatory variables and interaction terms x_1x_2 and x_1x_5 . We will call this model the full model.

- (i) (4 pts) Use SPSS to estimate the parameters of the model.
- (j) (4 pts) Produce the ANOVA table.
- (k) (4 pts) Produce a plot of residuals versus predicted values.
- (l) (4 pts) Produce a QQ plot for residuals.
- (m) (4 pts) Are the two interaction terms significant? Explain.
- (n) (4 pts) Is the model a good model? Let us assume that the theory is valid.
- (o) (4 pts) Which model, the reduced or the full model or neither model, is better? Explain.

2 Problem 2

2. **Question 2** Taken from McClave 12th edition problem 9.108 a, b, c, and d.

Improving the output of an industrial lathe. *Quality Engineering* (Vol. 6, 1994) reported the results of an experiment that was designed to find ways to improve the output of an industrial lathe. The lathe is controlled by a computer that automatically feeds bar stock, cuts the stock, machines the surface finish, and releases the part. As it is machined, the bar stock spins and is held in place by a collet. The lathe operator sets the feed (the rate at which bars are machined) and the speed (spin rate). The product characteristic of interest is surface finish. It is measured on a gauge that records the vertical distance a probe travels as it moves along a given horizontal distance on the bar. The rougher the surface, the higher the gauge measurement. The factors that were manipulated in the experiment were: speed, feed, collect tightness, and tool wear. The factor level settings are designated by H=High and L=Low. The set of data is called: LATHE.sav.

- (a) (4 pts) What type of experimental design was used?
- (b) (4 pts) How many different observations were made?
- (c) (4 pts) Perform an ANOVA for the full model having all possible interaction terms. (In Custom Box in SPSS, choose Full Model.)
- (d) (4 pts) Do significant interaction effects exist?

3 Problem 3

3. **Question 3** Taken from McClave 12th edition problem 13.13 and 13.29.

Pain levels of ICU patients. Various interventions are available for nurses to help relieve patients' pain (e.g. heat/cold applications, breathing exercises, massage). The journal *Research in Nursing & Health* (Vol. 35, 2012) demonstrated the utility of statistical process control in determining the effectiveness of a pain intervention. The researchers presented the following illustration. Pain levels (measured on a 100-point scale) were recorded for a sample of 10 intensive care unit (ICU) patients 24 hours post-surgery each week for 20 consecutive weeks.

The set of data is called: ICU.sav. **Note:** Ten measurements were taken each week; therefore, $n=10$ per week for 20 weeks. The sample mean of the ten measurements per week is contained in the set of data, ICU.sav which contains the 20 sample means and 20 sample ranges. The set of data, also, contains eight additional weeks of data after a certain pain intervention was applied in the ICU.

- (a) (4 pts) Using SPSS, construct a plot of \bar{x} versus WEEK which is along the x-axis.
- (b) (4 pts) Using SPSS, construct a plot of RANGE versus WEEK which is along the x-axis.
- (c) (4 pts) On the control chart template, plot the data for the first 20 weeks and draw by hand the UCL and the LCL for the \bar{x} chart and the UCL and LCL on RANGE versus WEEK plot. Show work in calculating the UCL's and LCL's.
- (d) (4 pts) After the 20th week, a pain intervention occurred in the ICU. The goal of the intervention was to reduce the average pain level of the ICU patients. To determine if the intervention was effective, the sampling of ICU patients was continued for eight more consecutive weeks. The mean pain levels of these patients were (in order): 71, 72, 69, 67, 66, 65, 64, and 62. Plot these additional points in red ink by hand on the \bar{x} chart. Note that these points are already in the SPSS data set.
- (e) (4 pts) The ranges of the pain levels for the samples of patients over the next eight consecutive weeks were (in order): 22, 29, 16, 15, 23, 19, 30, 32. Plot the additional points in red ink by hand on the RANGE chart. Note that these points are already in the SPSS data set.
- (f) (4 pts) Interpret the quality control chart in problems 3d and 3e as to the effectiveness of the pain intervention procedure.

4 Recipe for Using SPSS to Produce ANOVA

1. For factorial design problems like problems 2 and 3, use the following recipe to produce the ANOVA tables.

Choose → → → → . Put the factors in the right box. Under Options, choose Residual Plot, and under Graph, select Regression Variable Plots.

2. For the \bar{x} and R charts, use the following recipe.

Choose → → → → put y in and x in . Remember to draw the last remaining eight points on the \bar{x} and R charts by hand in red ink.