Statistics 495, Applied Statistics for Industry I

Final Exam, Fall 2008

Name: ____________________________

Site: ______________________________

INSTRUCTIONS: You will have 2 hours to complete the exam. There are 7 questions worth a total of 130 points. Not all questions have the same point value so gauge your time appropriately. Read the questions carefully and completely. Answer each question and show work in the space provided on the exam. Turn in the exam when you are done or when time is up. You do not have to turn in the JMP output. For essay questions, think before you write.

You may use the following materials for the exam.

- Formula sheet for gauge R&R
- Control Chart Construction handout
- Nelson’s tests for special causes handout
- Calculation of Average Run Length with
- Standard Normal Distribution handout
- Formula sheet for nested designs
- Formula sheet for the final exam
- JMP output for can filling process (included with final exam)
- JMP output for mold temperature study (included with final exam)
1. [25 pts] A can filling process has a target fill of 8.1 ounces with a tolerance of \( \pm 0.1 \) ounce. Thirty subgroups of size 2 are taken to check the stability and capability of the process. Refer to the JMP output for can-filling process.

   a) [3] Looking at the \( \bar{X} \) chart, and using the single point outside control limits alarm rule, what can you say about the stability of the process?

   b) [3] Looking at the R chart, and using the single point outside control limits alarm rule, what can you say about the stability of the process?

   c) [3] What is the value of the estimated process standard deviation based on the average range?

   d) [4] Using the estimate in c), compute an estimate of the process potential index. What does this value tell you about the capability of the process? Explain briefly.
e) [5] The value of $\hat{CP}$, using the average range to estimate the process standard deviation, is 0.580. What percentage of cans is predicted to be above the upper specification limit?

f) [2] How many of the 60 fill values in the study:

- fall below the lower specification limit?

- fall above the upper specification limit?

g) [2] What are the values of $\hat{C}_p$ and $\hat{C}_{pk}$ using the overall estimate of the process standard deviation?

h) [3] What does the comparison of $\hat{C}_p$ to $\hat{C}_{pk}$ tell you about the process? Explain briefly.
2. [25 pts] A study is conducted to investigate heat transfer in article molds used in making drinking glasses. Variability in mold temperature is of concern. Two factories are included in the study. At each factory, 2 disks are selected. Two molds are selected from each disk and 5 determinations of temperature are made on each mold. Refer to the JMP output for mold temperature study.

<table>
<thead>
<tr>
<th>Factory 1</th>
<th>Factory 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disk 1</td>
<td>Disk 1</td>
</tr>
<tr>
<td>Mold 1</td>
<td>Mold 2</td>
</tr>
<tr>
<td>458</td>
<td>471</td>
</tr>
<tr>
<td>466</td>
<td>467</td>
</tr>
<tr>
<td>464</td>
<td>467</td>
</tr>
<tr>
<td>471</td>
<td>472</td>
</tr>
<tr>
<td>463</td>
<td>469</td>
</tr>
</tbody>
</table>

a) [6] Looking at the variability chart for temperature comment on:
   - apparent differences between factories.
   - variation within molds.

b) [5] The eight standard deviations plotted on the run chart have an average value \( \bar{s} = 2.396 \). Compute the upper and lower control limits for these standard deviations. Do any of the standard deviations come close to or exceed the control limits? If so, which standard deviations are they?
c) [10] Calculate the estimates of the variance components and the percent of the total variance.

<table>
<thead>
<tr>
<th>Source</th>
<th>Estimated Variance Component</th>
<th>Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

d) [4] Where should quality improvement efforts be focused? Support your answer with results from c).
3. [10 pts] Capability analysis can have both enumerative and analytic purposes.
   
a) [6] Explain briefly what the enumerative purposes of a capability analysis are and what the analytic purposes of a capability analysis are.

   b) [4] For which purpose, enumerative or analytic, is stability of the process essential? Explain briefly.

4. [20 pts] A nationwide store orders 1,000,000 Rudolph's Light-Up Red Noses for sale over the holidays. The 1,000,000 noses are delivered to the national warehouse but before they are shipped to stores, 1,000 of the noses are selected at random to be tested to make sure there is no danger of a short circuit that could shock the wearer. To test a nose, the package is opened and the nose is placed on a testing device that checks the circuitry. If the testing reveals faulty circuitry, the nose is declared defective. After testing the nose, defective or non-defective is thrown away.

   a) [3] Explain briefly how you know that sampling is done without replacement?

   b) [4] Even though the sampling is done without replacement, explain briefly why using the binomial distribution (sampling with replacement) will give a good approximation to the hypergeometric distribution (sampling without replacement).
c) [4] Using the binomial distribution, what is the 95% upper bound for the proportion of defective noses in the shipment of 1,000,000 if none of the 1,000 noses tested are defective? Round your final answer to 3 decimal places.

d) [6] Suppose one of the 1,000 noses tested is found to be defective. Use the approximation to the binomial distribution to construct a 95% confidence interval for the proportion of defective noses in the shipment of 1,000,000. Round the final answer to 3 decimal places.

e) [3] How much of a difference does finding one defective nose have on the estimate of the maximum number of defective noses in the order compared to finding no defective noses?
5. [20 pts] A lot of 500 parts arrives at the loading dock. Before accepting the lot you can test some parts. Testing is destructive and you have to pay for the parts you test, even if you decide not to accept the lot. Suppose that there are 40 defective parts in the lot. Round final probabilities to 3 decimal places.
   a) [4] A random sample of 3 parts is selected and tested. If one or more parts are defective then the lot will be rejected. What is the probability the lot is rejected? Hint: It may be easier to compute the probability that the lot is accepted and use this to determine the probability that the lot is rejected.

b) [9] Another way to proceed is to reject the lot when you get the first defective part. Find the probability that you reject the lot on the:
   - first part tested?
   - second part tested?
   - third part tested?

c) [4] How do the two methods compare in terms of making a decision on the lot by testing at most 3 parts?

d) [3] Which method a) or b) would be less costly in terms of testing and paying for tested parts?
6. [18 pts] The following situations deal with different aspects in the production and packaging of breakfast cereal. For each situation indicate what control chart(s) you would use to monitor the quality characteristic of interest. Explain briefly your choice.

a) [6] Corn arrives at the cereal plant in large truck loads. For each load, a sample of corn is taken and sent to a laboratory for analysis to measure the moisture content.

b) [6] Corn with sufficiently low water content is put in the production hopper where it goes on to be turned into corn flakes. The corn flakes are put into 12 ounce packages. Subgroups of 5 packages are taken every 15 minutes and the contents weighed.

c) [6] Occasionally, the cereal company runs a promotion by putting an item (like a Sponge-Bob Square Pants Watch) in the box with the package of cereal. When this is done, subgroups of 100 boxes are selected periodically to see how many do not contain the promotion item.
7. [12] In the space provided (I will not read beyond the line) give the most important concept or “big idea” from this course. Briefly explain why it is important and comment on how it will affect the way you do your job. Focus on concepts rather than techniques. There is not a “correct” answer to this question. You will be graded on how well you express yourself. Think before you write.

Do not write in the space below.