IE 361 Exam 2
Fall 2006

I have neither given nor received unauthorized assistance on this exam.

________________________________________________________________________
Name                                        Date
This exam consists of 20 multiple choice questions. There is a single best answer for each question. 
**Circle EXACTLY ONE response** for each question on this answer sheet.

1. A  B  C  D  E  
2. A  B  C  D  E  
3. A  B  C  D  E  
4. A  B  C  D  E  
5. A  B  C  D  E  
6. A  B  C  D  E  
7. A  B  C  D  E  
8. A  B  C  D  E  
9. A  B  C  D  E  
10. A  B  C  D  E  
11. A  B  C  D  E  
12. A  B  C  D  E  
13. A  B  C  D  E  
14. A  B  C  D  E  
15. A  B  C  D  E  
16. A  B  C  D  E  
17. A  B  C  D  E  
18. A  B  C  D  E  
19. A  B  C  D  E  
20. A  B  C  D  E
1. The purpose of control charting is to
   a) detect process change.
   b) detect substandard process outcomes/output.
   c) separate special cause variation from common cause variation.
   d) All of responses a) through c) are correct completions of the sentence.
   e) Exactly 2 of responses a) through c) are correct completions of the sentence.

2. Unadjusted, a particular lathe used to cut rings in plastic cylinders is actually physically stable (and could be seen to be so by control charting individuals or mean ring diameters). But instead of doing control charting, an operator measures each ring diameter as it is made and adjusts the tool for cutting the next ring according to how the current one measures. (For example, if the current diameter is .001 in bigger than the target diameter, the tool is adjusted to cut an extra .001 inch off the diameter of the next one produced.) These adjustments
   a) will have no effect on consistency of ring diameters (over leaving the machine alone).
   b) are likely to improve the consistency of ring diameters (over leaving the machine alone).
   c) are likely to degrade the consistency of ring diameters (over leaving the machine alone).
   d) may affect consistency of ring diameters (over leaving the machine alone) but the nature of any such change is unpredictable.

3. Retrospective control charts
   a) are of more practical importance than standards given control charts.
   b) are based on a provisional assumption of process stability and estimation of process parameters.
   c) Both of a) and b) are correct completions of the sentence.
   d) Neither of a) and b) are correct completions of the sentence.

Below are sample means and standard deviations from 10 samples of size $n = 4$. Use the information from these samples to answer questions 4 through 6.

<table>
<thead>
<tr>
<th>Sample</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{x}$</td>
<td>7.0</td>
<td>7.9</td>
<td>7.1</td>
<td>7.7</td>
<td>5.2</td>
<td>5.4</td>
<td>6.4</td>
<td>6.5</td>
<td>5.8</td>
<td>6.8</td>
<td>65.8</td>
</tr>
<tr>
<td>$s$</td>
<td>1.5</td>
<td>3.1</td>
<td>3.4</td>
<td>1.1</td>
<td>1.4</td>
<td>1.0</td>
<td>2.5</td>
<td>0.7</td>
<td>1.4</td>
<td>1.1</td>
<td>17.2</td>
</tr>
</tbody>
</table>

4. Consider standards given control charting for both $\bar{x}$ and $s$, with standards $\mu = 6.0$ and $\sigma = 1.5$.
   a) The $\bar{x}$ chart and $s$ chart both produce out-of-control signals.
   b) The $\bar{x}$ chart produces out-of-control signals, but the $s$ chart does not.
   c) The $\bar{x}$ chart produces no out-of-control signals, but the $s$ chart produces signals.
   d) Neither chart produces out-of-control signals.

5. Consider retrospective control charting for both $\bar{x}$ and $s$.
   a) The $\bar{x}$ chart and $s$ chart both produce out-of-control signals.
   b) The $\bar{x}$ chart produces out-of-control signals, but the $s$ chart does not.
   c) The $\bar{x}$ chart produces no out-of-control signals, but the $s$ chart produces signals.
   d) Neither chart produces out-of-control signals.
6. Ignore any lack of stability that you found in the sample standard deviations on the previous page and use the values there to estimate \( \sigma \). Based on this estimate, in turn estimate the mean of a range (\( \bar{R} \)) for an additional sample of size \( n = 6 \). (Remember that the samples represented in the table were of size \( n = 4 \).) This estimate is closest to
   a) 1.87
   b) 3.54
   c) 3.84
   d) 4.36
   e) 4.73

7. Below are 3 statements about control charting. How many of them are true?
   - Median charting is less sensitive to process change than \( \bar{x} \) charting.
   - Control charting is a process improvement technique only to the extent that it helps bring process performance to the best level possible given its current configuration.
   - Process stability has no direct connection to product acceptability.
   a) All 3 are correct.
   b) Exactly 2 are correct.
   c) Exactly 1 is correct.
   d) None are correct.

8. A particular visual inspection method historically has only a 40% rate of correctly identifying nonconforming items. After some operator training, marked items known to be defective are mixed with current production (100 known defectives per shift) and sent through an inspection station. Standards given control limits for fractions of the defective items correctly identified on a given shift
   a) are .25 and .55.
   b) are .21 and .59.
   c) allow for detection of improved inspection performance when a sample detection rate is above the upper control limit.
   d) Both a) and c) are correct completions of the sentence.
   e) Both b) and c) are correct completions of the sentence.

9. Below are some records from inspection for paint defects on a model of large machine.

<table>
<thead>
<tr>
<th>Machine</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defects</td>
<td>9</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>50</td>
</tr>
</tbody>
</table>

   These data
   a) show no evidence of painting process instability when looked at retrospectively.
   b) provide clear evidence of a process improvement if a rate of 10 defects per machine has been "standard."
   c) are an example of "measurement" or "variables" data.
   d) Exactly 2 of a) through c) are correct completions of the sentence.
   e) All of a) through c) are correct completions of the sentence.

10. A positive lower control limit on a range chart
    a) allows the possibility of detecting unexpected "good" assignable causes.
    b) is available only for sample sizes of at least 7.
    c) means that for process parameters \( \mu \) and \( \sigma \) (for basic observations), it must be the case that \( \mu - 3\sigma > 0 \).
    d) Exactly 2 of a) through c) are correct completions of the sentence.
    e) All of a) through c) are correct completions of the sentence.
11. "Patterns" visible on a control chart
   a) suggest the presence of assignable cause variation even when no points reach control limits.
   b) can give hints regarding their physical source.
   c) motivate the creation of sets of "extra alarm rules" like the Western Electric Rules.
   d) Exactly 2 of a) through c) are correct completions of the sentence.
   e) All of a) through c) are correct completions of the sentence.

12. Using sets of "extra alarms rules" like the Western Electric Rules
   a) produces no effect on the "false alarm frequency" for a Shewhart $\bar{x}$ chart (compared to that of the single "one point outside 3-sigma limits" rule).
   b) reduces the "false alarm frequency" for a Shewhart $\bar{x}$ chart (below that of the single "one point outside 3-sigma limits" rule).
   c) increases the "false alarm frequency" for a Shewhart $\bar{x}$ chart (over that of the single "one point outside 3-sigma limits" rule).
   d) affects the "false alarm frequency" for a Shewhart $\bar{x}$ chart (relative to that of a single "one point outside 3-sigma limits" rule), but the nature of that effect can not be predicted.

13. Process standards are $\mu = 100$ and $\sigma = 7$ and observations from the process are normally distributed. Below are 3 statements about Shewhart $\bar{x}$ charts for this process. How many of them are true?
   • Charts for $n = 5$ and $n = 10$ have the same control limits.
   • Charts for $n = 5$ and $n = 10$ have the same ARL if process parameters remain at standard values.
   • Charts for $n = 5$ and $n = 10$ have the same ARL if the process mean changes from the standard value.
   a) All 3 are correct.
   b) Exactly 2 are correct.
   c) Exactly 1 is correct.
   d) None are correct.

14. If process standards for a normally distributed variable are $\mu = 100$ and $\sigma = 7$ and specifications on the variable are $100 \pm 10$, based on samples of size $n = 4$
   a) it is impossible to use a Shewhart $p$ chart to do process monitoring.
   b) it is possible to use a Shewhart $p$ chart to do process monitoring, with the standard value of $p = .0027$.
   c) it is possible to use a Shewhart $p$ chart to do process monitoring, with a standard value of $p = .0042$.
   d) it is possible to use a Shewhart $p$ chart to do process monitoring with a standard value of $p = .1528$.
   e) it is possible to use a Shewhart $p$ chart to do process monitoring with a standard value of $p = .2420$.

15. In comparing two methods of control charting, Method A is clearly preferable to Method B relative to "All OK" and some "not All OK" process condition if
   a) $ARL_A > ARL_B$ when "All is OK" and $ARL_A > ARL_B$ when "All is not OK."
   b) $ARL_A > ARL_B$ when "All is OK" and $ARL_A < ARL_B$ when "All is not OK."
   c) $ARL_A < ARL_B$ when "All is OK" and $ARL_A > ARL_B$ when "All is not OK."
   d) $ARL_A < ARL_B$ when "All is OK" and $ARL_A < ARL_B$ when "All is not OK."
16. 10 consecutive samples of size $n = 1$ from a process are as below

<table>
<thead>
<tr>
<th>Sample</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x$</td>
<td>1.01</td>
<td>2.03</td>
<td>.98</td>
<td>1.97</td>
<td>.95</td>
<td>1.97</td>
<td>.97</td>
<td>2.07</td>
<td>.96</td>
<td>1.97</td>
<td>1.488</td>
</tr>
<tr>
<td>$MR$</td>
<td>1.02</td>
<td>1.05</td>
<td>.99</td>
<td>1.02</td>
<td>1.02</td>
<td>1.00</td>
<td>1.10</td>
<td>1.11</td>
<td>1.01</td>
<td>1.036</td>
<td>1.0356</td>
</tr>
</tbody>
</table>

Further, $\frac{1.0356}{1.128} = .918$

a) A retrospective individuals chart based on the best available estimate of $\sigma$ indicates there is process instability, and this analysis appears to be appropriate.

b) A retrospective individuals chart based on the best available estimate of $\sigma$ indicates no process instability, and this analysis appears to be appropriate.

c) A retrospective individuals chart based on the best available estimate of $\sigma$ indicates there is process instability, but the very regular and relatively large cycles in the data make it clear that this estimate and analysis are inappropriate.

d) A retrospective individuals chart based on the best available estimate of $\sigma$ indicates no process instability, but the very regular and relatively large cycles in the data make it clear that this estimate and analysis are inappropriate.

17. Below are 3 statements about normal plots (normal quantile plots in \textit{JMP} language). How many of them are true?

- "Near linearity" on such a plot means that the process generating the data was in control during data collection.
- When the plot is reasonably linear, its slope is closely related to data set variability.
- When most of a normal plot is reasonably linear but the lower left point on the plot looks as if it is "pulled left" away from the line established by the rest of the points, there is indication that a normal model would understate the fraction of "small" values produced by a stable process leading to the data set.

a) All 3 of the statements are true.

b) Exactly 2 of the statements are true.

c) Exactly 1 of the statements is true.

d) None of the statements is true.

Data from problem 5.8 of \textit{SQAME} are measured hardness values from $n = 8$ heat-treated steel parts produced on a single day. These have $\bar{x} = 3.150$ mm, $s = .0443$ mm, min $x_i = 3.100$ mm, and max $x_i = 3.200$ mm. We'll assume that specifications on this hardness are $3.100 \pm .150$ mm. Use these facts to answer questions 18 through 20.

18. Assuming hardness to be normally distributed, what are limits you are "95% sure" would bracket one more (a 9th) part hardness value?

a) 3.100 mm and 3.200 mm

b) 3.150 $\pm .036$ mm

c) 3.150 $\pm .037$ mm

d) 3.150 $\pm .108$ mm

e) 3.150 $\pm .111$ mm
19. Again assuming hardness to be normally distributed, 95% confidence limits for a capability ratio measuring current process performance (as opposed to process potential)
   a) are .18 mm and .54 mm.
   b) are .55 and 1.71.
   c) are .30 and 1.21.
   d) None of the above are close to correct.

20. Again assuming hardness to be normally distributed, 95% confidence limits for a capability ratio measuring process potential (as opposed to current process performance)
   a) are .18 mm and .54 mm.
   b) are .55 and 1.71.
   c) are .30 and 1.21.
   d) None of the above are close to correct.