IE 361 Exam 2
Fall 2012

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

________________________________________________________________________

Name Signed                        Date

________________________________________________________________________

Name Printed
1. Over 40 shifts of production, a total of 5470 LED displays were made and inspected. A total of 430 nonconformities were identified on those 5470 displays, and 194 of the displays were judged to be nonconforming. A retrospective analysis of the data from the 40 shifts found no evidence of process instability over that period, and so these historical rates will here be taken as standard values.

14 pts  a) In a subsequent shift, 200 displays are produced. A total of 18 nonconformities are identified on these, and 13 of the displays are judged to be nonconforming. Do either of these counts provide clear evidence of process change? (Compare the two counts to appropriate control limits and interpret your result.)

| 18 nonconformities | 13 nonconforming |

Interpretation:

6 pts  b) Suppose that at some point in the future, the standard rate of nonconforming displays is reduced, production is increased to 300 displays per shift, and a process monitoring system is adopted that signals "out of control"/"intervention warranted" if there are 3 or more nonconforming displays produced. If, in fact, a fraction .005 of all displays produced are nonconforming, what is the probability that the next shift will have an "out of control" signal?
2. Lengths of steel shafts are measured by a laser gauge that produces a coded voltage proportional to shaft length (above some reference length). In the units produced by the gauge, shafts of a particular type have length specifications $2300 \pm 20$. Below are measured lengths of $n = 8$ such shafts.

$$2298, 2289, 2291, 2290, 2290, 2287, 2280, 2289$$

Assume that these shafts were produced by a physically stable process.

**6 pts** a) How confident are you that an 9th shaft produced by this process would measure at least $2280$? (Give a number.)

Henceforth assume that it is sensible to model shaft length as normally distributed. For the lengths listed above, $\bar{x} = 2289.3$ and $s = 4.9$.

**7 pts** b) Give 90% two-sided confidence limits for a process capability index that measures process potential. (Plug in completely, but you need not simplify.)

**7 pts** c) Give a 95% lower confidence bound for a process capability index that measures current process performance. (Plug in completely, but you need not simplify.)
3. IE 361 students did a class project with a company that cuts rolled paper into sheets. The students periodically sampled $n = 10$ consecutive sheets as they were cut and measured their lengths. 15 samples are summarized below. (The measurements were in 64ths of an inch above nominal.)

<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>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>Σx</th>
<th>Σs</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>12.2</td>
<td>11.2</td>
<td>10.6</td>
<td>12.2</td>
<td>11.2</td>
<td>12.6</td>
<td>12.2</td>
<td>13.6</td>
<td>12.2</td>
<td>10.4</td>
<td>10.4</td>
<td>10.6</td>
<td>10.4</td>
<td>12.0</td>
<td>11.2</td>
<td>171</td>
<td>26.18</td>
</tr>
<tr>
<td>s</td>
<td>.84</td>
<td>1.64</td>
<td>2.07</td>
<td>2.49</td>
<td>.84</td>
<td>1.82</td>
<td>2.95</td>
<td>1.67</td>
<td>1.30</td>
<td>1.52</td>
<td>1.95</td>
<td>1.67</td>
<td>1.67</td>
<td>2.91</td>
<td>.84</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**14 pts**

a) What do these values indicate about the stability of the cutting process? (Show work and consider both process mean and standard deviation.)

**6 pts**

b) If one judges the process to be stable and sheet length to be normally distributed, it is possible to estimate the fraction of sheets below nominal in length. Do this. (Show your work.)
c) Each inch that the cutting process mean is above nominal represents a $200,000/year loss to the company from product "given away." On the other hand, the company wants to be sure that essentially no sheets are produced with below-nominal lengths. With this in mind, what adjustment in mean length do you suggest, and what yearly savings or additional costs do you project assuming this adjustment is made?

d) Suppose that the adjustment you recommend in c) is made and henceforth the cutting process is to be monitored based on samples of size \( n = 5 \). Give control limits for future monitoring of \( \bar{x} \) and \( s \).
4. Short Answers. (5 points apiece.) Write only a sentence or two (no more than 25 words) for each.

a) State the goal of control charting and appropriate action on out-of-control signals.

b) Why might it be argued that the name "control" chart invites confusion?

c) Although statistical quality control tools have been applied primarily in manufacturing industries, they also have important applications in service industries. Which step in the process improvement cycle seems relatively most difficult in service contexts? Explain.

d) Distinguish between "quality of design" and "quality of conformance." With which of these is control charting concerned?