IE 361 Exam 2
Spring 2011

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

________________________________________________________
Name                Date
Below are 25 True-False Questions, worth 2 points each. Write one of "T" or "F" in front of each.

_____ 1. The percent impurity in one fluid ounce of a liquid product is tested and plotted once per hour in a production facility. The appropriate control chart limits are $p$ chart limits.

_____ 2. A mean number of non-conformities per unit plotted on Shewhart control chart can exceed 1.0.

_____ 3. The upper standards given control limit for ranges increases as the sample size increases.

_____ 4. The upper standards given control limit for standard deviations increases as the sample size increases.

_____ 5. Upper and lower standards given control limits for fractions non-conforming get further apart as the sample size increases.

_____ 6. A point plotting outside of control limits on a Shewhart chart always suggests process degradation.

_____ 7. A standard "$\sigma$" used in setting $\bar{x}$ chart control limits represents only "process" variation.

_____ 8. Engineering specifications on dimension A are 1.00' ± .02', while specifications on dimension B are 1.00' ± .01'. Then samples of size $n = 5$ must produce $\bar{x}$ chart control limits that are tighter for dimension B than for dimension A.

_____ 9. Engineering feedback control can play a part in establishing industrial process stability that is then monitored using statistical process control.

_____ 10. "Special cause variation" is another name for "process change" that Shewhart control charting is meant to detect.

_____ 11. Retrospective control limits are meant to help answer the question "Are process parameters at their standard values?"

_____ 12. Statistical tolerance limits are intended to indicate the requirements on a measurement in order for a corresponding item to be functional.

_____ 13. Statistical prediction limits are intended to locate most of the future output of a stable process based on a sample from that process.

_____ 14. $C_{pk}$ is a measure of present process performance (rather than process potential).

_____ 15. If a 95% confidence interval for $C_{pk}$ is (1.5, 1.7) then it is reasonably clear that a "6 sigma" process performance goal has been achieved.
16. The ARL concept is a tool for aiding the choice/design of a process monitoring scheme, in that it is a quantification of monitoring scheme performance under a particular model of process behavior.

17. The "Western Electric Alarm Rules" are meant to provide the ability to quickly detect non-random patterns on a Shewhart chart.

18. Tool wear in a turning process that would naturally make consecutively machined cylinders increase in size can potentially be compensated for by the use of engineering feedback control.

19. A physically stable process will of necessity produce acceptable product.

20. Trends on an individuals chart tend to make the corresponding value of $\frac{\bar{MR}}{1.128}$ "too small" as an estimate of $\sigma$.

21. Two different machining centers produce supposedly identical cylinders. A consistent difference between those machines (in terms of diameters produced) if ignored would produce "sample" averages of two diameters from each machine that would tend to look "too/unbelievably stable."

22. Samples (or rational subgroups) of size $n = 1$ make completely reliable estimation of $\sigma$ impossible.

23. If a process has a number of known "knobs" that can be used to change an output variable, $y$, establishing a level of "baseline" variation for $y$ might be done by holding those fixed and control charting process output.

24. Lack of physical stability means that basic changes to process configuration or operation are necessary in order to reduce observed variation.

25. Normal plotting and confirmation of a normal distributional shape are necessary before it is possible to make any form of statistical prediction limits.

The next 5 pages each have a 10 point "work out" problem on them (numbered W1, W2, W3, W4, and W5). Answer all 5.
W1. Below are some means and standard deviations for samples of size $n = 3$ surface roughness measurements (units are $\mu$-inches).

<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>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{x}$</td>
<td>19.4</td>
<td>19.2</td>
<td>21.1</td>
<td>19.8</td>
<td>19.9</td>
<td>19.6</td>
<td>20.3</td>
<td>19.7</td>
<td>18.7</td>
<td>20.1</td>
</tr>
<tr>
<td>$s$</td>
<td>.3</td>
<td>1.5</td>
<td>2.0</td>
<td>1.6</td>
<td>1.8</td>
<td>1.3</td>
<td>.9</td>
<td>1.2</td>
<td>.7</td>
<td>.9</td>
</tr>
</tbody>
</table>

$\sum \bar{x} = 197.8 \quad \sum s = 12.2$

Suppose that process standards are $\mu = 20$ and $\sigma = 1$. Is there evidence of change from these standard values in these data? Show appropriate calculations and explicitly say whether there is any evidence of change from the process standard values.

Evidence of change from standard values? (Circle the correct response.)

In means?  yes/no  
In standard deviations? yes/no
W2. Below are numbers of radiators inspected and total leaks found in those inspections over a number of 1 hour periods.

<table>
<thead>
<tr>
<th>Period</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>
</tr>
</thead>
<tbody>
<tr>
<td>Leaks</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Number Inspected</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

\[ \sum \text{Leaks} = 16 \]

Total = 20

Determine whether there is any evidence of process instability in these data. Show appropriate calculations and say clearly where (if at all) there is evidence of instability.
W3. Below is a JMP report for $n = 25$ measured weld strengths (units are psi).

![Fitted Normal Parameter Estimates](image)

a) Why is consideration of the kind of plot shown here wise before considering process capability measures?

b) Specifications on such strengths are 1100 psi to 1800 psi. Give 95% confidence limits for $C_{pk}$.
W4. Suppose that a pelletizing process is physically stable, producing constant fraction non-conforming $p$. Samples of size $n = 100$ are used to do Shewhart control charting with standard value $p = .2$.

a) What is the ARL if $p$ is at its standard value?

b) What is the ARL if $p$ is twice its standard value?
W5. Below is an artificial series of observations (samples of size $n = 1$) collected from consecutive items (suppose the units are inches).

$$2, 4, 6, 8, 10, 12, 14, 16, 18, 20$$

a) How does the best available estimate of "$\sigma$" here (based on control charting ideas) compare to the sample standard deviation? Provide some rationale why the larger of these is larger.

b) Set up control limits for future monitoring of individual measurements of this type using a process mean of 10 and an appropriate estimate of process standard deviation.