IE 361 Exam 2
(With "Clarified Version" of Question #3)
Fall 2007

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

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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. Control charting
   a) is a form of Engineering Feedback Control.
   b) compares individual process measurements to specifications in order to check for lack of process stability.
   c) is most effective as a quality assurance tool when applied at the end of a production chain, a substantial distance in time and space from processes being monitored.
   d) None 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. Control limits for a generic plotted statistic Q
   a) are typically derived from a probability model for Q appropriate when individual process outcomes are modeled as "independent draws from a fixed universe."
   b) typically depend upon the size of the sample used to compute Q.
   c) typically depend upon process parameters.
   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.

3. In standards-given variables control charting with sample size n and process standards μ and σ,
   a) the difference between $UCL_{\bar{x}}$ and $LCL_{\bar{x}}$ always shrinks as n increases (the spread in control limits gets smaller as sample size increases).
   b) the difference between UCL_s and LCL_s always shrinks as $n \geq 6$ increases (the spread in control limits gets smaller as sample size increases).
   c) the difference between UCL_R and LCL_R always shrinks as $n \geq 7$ increases (the spread in control limits gets smaller as sample size increases).
   d) All of responses a) through c) are correct completions of the sentence.
   e) Exactly 2 of responses a) and b) are correct completions of the sentence.

Below are sample means and ranges from 10 samples of size $n = 5$. Use the information from these samples to answer questions 4 through 6.

Sample	1	2	3	4	5	6	7	8	9	10	Sum
$\bar{x}$	11.0	11.9	9.7	10.0	11.1	11.3	11.0	11.5	11.1	12.6	111.2
R	2.1	6.0	3.9	4.5	3.9	5.8	6.0	5.2	2.9	6.8	47.1

4. Consider standards given control charting for both $\bar{x}$ and R, with standards $\mu = 11.0$ and $\sigma = 2.0$.
   a) The $\bar{x}$ chart and R chart both produce out-of-control signals.
   b) The $\bar{x}$ chart produces out-of-control signals, but the R chart does not.
   c) The $\bar{x}$ chart produces no out-of-control signals, but the R chart produces signals.
   d) Neither chart produces out-of-control signals.

5. Consider retrospective control charting for both $\bar{x}$ and R.
   a) The $\bar{x}$ chart and R chart both produce out-of-control signals.
   b) The $\bar{x}$ chart produces out-of-control signals, but the R chart does not.
   c) The $\bar{x}$ chart produces no out-of-control signals, but the R chart produces signals.
   d) Neither chart produces out-of-control signals.

6. Ignore any lack of stability that you may have found in the sample ranges on the previous page and use the values there to estimate σ. Based on this estimate, in turn set an upper control limit for the sample standard deviation (s) for an additional sample of size $n = 4$. (Remember that the samples represented in the table were of size $n = 5$.) This limit is closest to

a) 2.02.
b) 3.98.
c) 4.23.
d) 9.51.
e) 9.96.

7. Below are 3 statements about control charting. How many of them are true?

- R charting is less sensitive to process change than s charting.
- Small sample sizes deprive one of the possibility of directly detecting unexpected improvements in process "spread" using ordinary three-sigma Shewhart control charts.
- If one uses only an $\bar{x}$ chart (and no R or s chart) it is impossible to detect a huge increase in process "spread."

a) All 3 are correct.
b) Exactly 2 are correct.
c) Exactly 1 is correct.
d) None is correct.

8. In a particular "mean nonconformities per unit" context, a process standard rate is 1.5 nonconformities per single inspection unit. A redesign of some elements of the production process is intended to reduce that rate/improve the process. After implementation of the redesign, a standards given Shewhart control charting scheme will be set up to monitor nonconformities per unit based on k inspection units per sampling period.

a) *Neither* a $k = 2$ scheme nor a $k = 8$ scheme *will* provide the ability to directly confirm a process improvement.
b) A $k = 2$ scheme *will not* provide the ability to directly confirm a process improvement, but a $k = 8$ scheme *will* provide this ability.
c) A $k = 2$ scheme *will* provide the ability to directly confirm a process improvement, but a $k = 8$ scheme *will not* provide this ability.
d) *Both* a $k = 2$ scheme and a $k = 8$ scheme *will* provide the ability to directly confirm a process improvement.
e) Not enough information is given here to tell whether any particular choice of k will provide the possibility of directly confirming process improvement.

9. Below are some records from inspection for counts of loose bolts (after torquing) on a model of large machine. (Each machine has 120 such bolts that are all checked.)

Machine	1	2	3	4	5	6	7	8	9	10	Sum
Loose Bolts	11	6	6	7	8	6	6	10	5	9	74

Appropriate retrospective control limits for the counts in the table above

a) are 7.4 ± 7.9.
b) are 7.4 ± 8.2.
c) indicate process stability.
d) a) and c) are both correct completions of the sentence.
e) b) and c) are both correct completions of the sentence.

10. Standards given control limits for $\bar{x}$ based on samples of size $n = 5$ are 17 ± 2.
 a) Corresponding standards given control limits for sample medians are 17 ± 2.4.
 b) Corresponding engineering specifications on x must be 17 ± 2.7.
 c) Corresponding standards given control limits for s are impossible to determined based on this information.
 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. Plotted points "hugging the center line" on a Shewhart $\bar{x}$ chart
 a) could be produced by an unexpected decrease in the process standard deviation, σ.
 b) are the ideal, indicating a very stable process.
 c) will fail to be directly detected by any of the "Western Electric Alarm 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. Five nominally identical production streams
 a) should be treated as a single stream for purposes of process monitoring.
 b) can produce a "rational subgroup" if one outcome is sampled from each stream at a given period.
 c) are best monitored using 5 separate control charts.
 d) Exactly 2 of a) through c) are correct completions of the sentence.
 f) All of a) through c) are correct completions of the sentence.

13. Process standards are $\mu = 100$ and $\sigma = 7$ and observations from the process are normally distributed. Below are 3 statements about a standards-given Shewhart $\bar{x}$ chart for this process. How many of them are true?

- The chart has the same ARL when $\mu = 100$ and $\sigma = 7$ as does a standards given $\bar{x}$ chart for a process with standards $\mu = 15$ and $\sigma = .7$ when in fact $\mu = 15$ and $\sigma = .7$.
- The ARL for this chart when $\mu = 100$ and $\sigma = 5$ is more than 370.
- The ARL for this chart when $\mu = 100$ and $\sigma = 9$ is less than 370.

 a) All 3 are correct.
 b) Exactly 2 are correct.
 c) Exactly 1 is correct.
 d) None is correct.

14. Flaws are generated in the production of carpet at a standard rate of 1 per 20 square yards of carpet. Certain 5 square yard rugs are inspected for flaws and a rug is considered to be non-conforming if it has any flaws on it. 10 of these rugs are inspected per hour. Let

X = the total number of flaws seen across the 10 rugs, and

Y = the number of non-conforming rugs among the 10

Standards given control limits for X and Y are
 a) respectively 2.5 ± 4.7 and 2.5 ± 4.1.
 b) respectively 2.5 ± 4.7 and 2.2 ± 4.5.
 c) respectively 2.5 ± 4.7 and 2.2 ± 3.9.
 d) impossible to determine from the given information.
 e) None of a) through d) is a correct completion of the sentence.

15. "Online"/ongoing process tweaking/adjustment
 a) is never an appropriate variation reduction methodology.
 b) requires having a process "knob" that one can "turn" with predictable results in response to a process mis-adjustment.
 c) is an alternative to control charting (having the same realm of application as Shewhart charting).
 d) None of a) through c) is a correct completion of the sentence.
 e) Exactly 2 of a) through c) are correct completions of the sentence.

16. 10 consecutive samples of size $n = 1$ from a process are as below

Sample	1	2	3	4	5	6	7	8	9	10	Mean
x	1.01	2.03	2.98	3.97	4.95	5.97	6.97	8.07	8.96	9.97	5.488
MR		1.02	.95	.99	.98	1.02	1.00	1.10	.89	1.01	.9956

Further,

$$.9956 / 1.128 = .883$$

 a) A retrospective individuals chart based on the best available estimate of σ indicates there is process instability, and this estimate and analysis appear to be appropriate.
 b) A retrospective individuals chart based on the best available estimate of σ indicates no process instability, and this estimate and analysis appear to be appropriate.
 c) A retrospective individuals chart based on the best available estimate of σ indicates there is process instability, but the clear linear trend in the data makes it clear that this estimate is inappropriate.
 d) A retrospective individuals chart based on the best available estimate of σ indicates no process instability, but the clear linear trend in the data makes it clear that this estimate is inappropriate.

17. Normal plots (normal quantile plots in JMP language)
 a) will always be approximately linear if a sample of size at least 30 is represented.
 b) are tools for assessing the extent to which one should trust the confidence levels associated with the intervals for $6\sigma, C_p$, and C_{pk} and the normal-based prediction and tolerance intervals of Chapter 5 of *SQAME*.
 c) are tools for assessing whether C_p and C_{pk} are relevant descriptors of process capability.
 d) Exactly 2 of responses a) through c) are correct.
 e) All of responses a) through c) are correct.

Data from problem 5.15 of *SQAME* include measured diameters from $n = 20$ 3-inch rolled sheet metal saddles produced on a single day. These have $\bar{x} = 3.0377$ in , $s = .0606$ in , $\min x_i = 2.969$ in , and $\max x_i = 3.188$ in . Specifications on this diameter are $3.00 \pm .20$ in . Use these facts to answer questions 18 through 20.

18. Assuming diameter to be normally distributed, what are limits that you are "at least 90% sure" would bracket one more (a 21st) saddle diameter?
 a) 2.969 in and 3.118 in .
 b) $3.0377 \pm .1074$ in .
 c) $3.0377 \pm .0606$ in .
 d) either response a) or response b) could be correctly used.
 e) either response a) or response c) could be correctly used.

19. If one assumes that the saddle-rolling process produces normally distributed diameters, 95% confidence limits for a capability ratio measuring current process performance

a) are .57 and 1.21.
b) are .75 and 1.45.
c) could be used to help evaluate whether a company "Six Sigma Program" goal is being met by seeing where the limits are relative to the value 2.0.
d) Both a) and c) are correct completions of the sentence.
e) Both b) and c) are correct completions of the sentence

20. Assuming diameter to be normally distributed, 95% confidence limits for the "process capability," 6σ

a) are .28 in and .53 in.
b) are .21 in and .77 in.
c) are .05 in and .09 in.
d) can not be determined from the information provided.
e) can be determined from the information provided, but are not close to any of the limits provided in a) through c).