IE 361 Exam 1
Fall 2007

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. "Quality of conformance"
   a) can in all cases only be achieved using state-of-the art processes
   b) is concerned with the appropriateness of features and configuration of a product
   c) has to do with small variation
   d) Exactly 2 of the responses a) through c) are correct completions of the sentence.
   e) None of the responses a) through c) are correct completions of the sentence.

2. The "continuous improvement" emphasis in modern quality assurance
   a) essentially requires a "process orientation"
   b) is a practical necessity in a competitive global business environment
   c) can be thought of in ethical terms as "the way things 'should' be"
   d) Exactly 2 of the responses a) through c) are correct completions of the sentence.
   e) All of the responses a) through c) are correct completions of the sentence.

3. Several modes on a histogram showing measured diameters of axels produced by a turning process suggest
   a) multiple versions of some element in the production process
   b) multiple versions of the measurement process
   c) multiple versions of both some element of the production process and of the measurement process
   d) multiple versions of some element of the production process, or of the measurement process, or both
   e) None of the responses a) through d) is a correct completion of the sentence.

4. Process analysis tools like flowcharts and Ishikawa diagrams
   a) can help identify important data needs
   b) are really only useful when working on very simple and technologically mature processes
   c) should be employed early in a process improvement effort
   d) Exactly 2 of the responses a) through c) are correct completions of the sentence.
   e) All of the responses a) through c) are correct completions of the sentence.

5. Regarding basic concepts of metrology,
   a) a problem with measurement validity can be addressed through a calibration study
   b) a bathroom scale that is broken and always reads 150lbs is nevertheless a "precise" device
   c) "accuracy" and "precision" are different words for the same concept
   d) Exactly 2 of the responses a) through c) are correct completions of the sentence.
   e) None of the responses a) through c) are correct completions of the sentence.

6. "Linearity" (in the sense that metrologists use the word) of a measurement device
   a) holds if \( \text{average measurement} = 2 \times (\text{measurand}) \)
   b) holds if \( \text{average measurement} = 3 + \text{measurand} \)
   c) holds if \( \text{average measurement} = 3 + 2 \times (\text{measurand}) \)
   d) Exactly 2 of the responses a) through c) are correct completions of the sentence.
   e) All of the responses a) through c) are correct completions of the sentence.
Fact: The upper 2.5% point of the $F_{2,2}$ distribution is about 39.0.

7. The same specimen of 20lb bond paper is weighed $n_1 = 3$ times on scale #1 and $n_2 = 3$ times on scale #2, with resulting means and standard deviations $\bar{y}_1 = 3.4760$g, $\bar{y}_2 = 3.4633$g, $s_1 = .0056$g, and $s_2 = .0133$g. Based on 95% confidence limits made from these values, one can conclude
   a) that there is no clear difference in either scale biases or standard deviations
   b) that there is no clear difference in scale biases, but there is a clear difference in scale standard deviations
   c) that there is a clear difference in scale biases, but no clear difference in scale standard deviations
   d) that there are clear differences in both scale biases and in scale standard deviations
   e) One of a) through d) is a correct completion of the sentence and sample sizes are large enough to see definitively which scale is most accurate.

8. Two different specimens of 20lb bond paper are weighed respectively $n_1 = 3$ and $n_2 = 3$ times on the same scale with resulting means and standard deviations $\bar{y}_1 = 3.4760$g, $\bar{y}_2 = 3.2567$g, $s_1 = .0056$g, and $s_2 = .0133$g. Based on 95% confidence limits made from these values, one can conclude
   a) that there is no clear difference between weights of the specimens
   b) that there is a clear difference between weights of the specimens
   c) nothing about the true weight of specimen #1
   d) Both a) and c) are correct completions of the sentence.
   e) Both b) and c) are correct completions of the sentence.

(For questions 9 and 10) A student group studied the densities of some $\text{Nd}_2\text{O}_3$ pellets produced by a stable production process. Densities of 6 different pellets were measured and the resulting values had sample mean 5.70g/cc and standard deviation .80g/cc. The density of a 7th pellet was measured 5 times and the resulting values had mean 4.60g/cc and standard deviation .25g/cc.

9. 95% confidence limits for a true mean pellet density for this process
   a) are $5.70 \pm .83$g/cc
   b) are $5.70 \pm 2.06$g/cc
   c) are $4.60 \pm .31$g/cc
   d) are $4.60 \pm .69$g/cc
   e) can not be determined from the given information

10. Approximate 95% confidence limits for a specimen-to-specimen standard deviation of actual pellet density
    a) can not be determined from the given information
    b) are .15g/cc and .72g/cc
    c) are .46g/cc and 2.18g/cc
    d) are .50g/cc and 1.96g/cc
    e) None of responses a) through d) is a correct completion of the sentence.
(For questions 11 and 12) Below is part of a JMP report from a "one-way random effects" analysis of a study where an operator used the same gauge to measure the heights of 10 steel punches 3 times apiece. (The data were actually those of student 1 in Table 2.1 of SQAME.) Units used entering the data were .001 inches.

![Variance Component Estimates Table]

11. In units of .001 inch, 95% confidence limits for the repeatability standard deviation in this context
   a) are not available based on the given information
   b) are 0 and 4.02
   c) are 0 and 2.01
   d) are .64 and 2.29
   e) are .80 and 1.51

12. In units of .001 inch, 95% confidence limits for the standard deviation of actual punch heights
   a) are not available based on the given information
   b) are 0 and 4.02
   c) are 0 and 2.01
   d) are .64 and 2.29
   e) are .80 and 1.51

13. Below is an ANOVA table from a small gauge R&R study where the same scale was used to measure the weights of $I = 2$ pieces of 20lb bond paper, $m = 3$ times each by $J = 5$ different operators. The original data were in grams.

   **ANOVA Table for Weight**

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piece</td>
<td>.37386</td>
<td>1</td>
<td>.37386</td>
</tr>
<tr>
<td>Operator</td>
<td>.00061</td>
<td>4</td>
<td>.000152</td>
</tr>
<tr>
<td>Piece×Operator</td>
<td>.00013</td>
<td>4</td>
<td>.000032</td>
</tr>
<tr>
<td>Error</td>
<td>.00095</td>
<td>20</td>
<td>.000047</td>
</tr>
<tr>
<td>Total</td>
<td>.37555</td>
<td>29</td>
<td></td>
</tr>
</tbody>
</table>

Based on the values in this table, a single number estimate of the reproducibility standard deviation, $\sigma_{\text{reproducibility}}$, are

   a) can not be determined
   b) is .0012g
   c) is .004g
   d) is .007g
   e) is .008g
14. In the context of problem 13, specifications on the weight of a piece of paper this size are some value ± 0.080g so that the difference between the upper and lower specifications is 0.160g. It is possible to determine from the values in the ANOVA table here that $\hat{\sigma}_{R&R} \approx 0.08$g and that $\nu_{R&R} = 17$. Approximate 95% confidence limits for a precision-to-tolerance ratio (a GCR) for checking conformance to these specifications

a) are 0.00375 and 0.075 and indicate that the scale is adequate for this purpose
b) are 0.00375 and 0.075 and call into question the adequacy of the scale for this purpose
c) are 0.225 and 0.45 and indicate that the scale is adequate for this purpose
d) are 0.225 and 0.45 and call into question the adequacy of the scale for this purpose.
e) None of the responses a) through d) is a correct completion of the sentence.

15. In a particular gauge R&R problem, 95% confidence limits on $\sigma_{\text{repeatability}}$ are 0.1 to 0.3, while 95% confidence limits on $\sigma_{\text{reproducibility}}$ are 1.8 to 2.4, all in the original units of measurement. These results suggest

a) differences between operator biases are a relatively important part of measurement variation
b) single measurements of the same part by many operators would have a substantially larger variability than many measurements of a single part by a fixed operator
c) creation of a standard measurement protocol and operator training might substantially reduce measurement variation
d) Exactly 2 of responses a) through c) are correct completions of the sentence.
e) All of responses a) through c) are correct completions of the sentence.

Below is a part of a JMP report from the analysis of a calibration data set. The data are from a weighing exercise, where $n = 14$ specimens of "known" weights $x$ were weighed on a scale, producing measurements $y$. All units were kg. Use the information on this report to answer questions 16 and 17.
16. In approximate terms, a specimen of known weight \( x = 9.00 \)kg weighed tomorrow on this scale could be expected to weigh
a) \( 9.00 \pm 2 \times 0.052 \)kg
b) \( 9.00 \pm 2 \times 0.027 \)kg
c) \( 9.00 \pm 2 \times 0.003 \)kg
d) None of a) through c) is close to being an appropriate completion of this sentence.

17. "Linearity" of this scale (in the meaning of the word as employed in metrology) is evident from the report because
a) the curves plotted on the graph are approximately straight lines
b) 95% confidence limits for the slope, \( \beta_1 \), include 1.0
b) 95% confidence limits for the slope, \( \beta_1 \), do not include 0
d) 95% confidence limits for the intercept, \( \beta_0 \), include 0
e) 95% confidence limits for the repeatability standard deviation will be based on \( \nu = 12 \) df

(For questions 18-20) Here is a small hypothetical data set from a study of go/no-go inspection of 4 parts by 3 operators. Each operator (without being aware that a given part was being re-inspected) made 100 good/defective calls on each part. The values in the table are \( \hat{p} \) values (fractions of "defective" calls made by the operators).

<table>
<thead>
<tr>
<th></th>
<th>Operator 1</th>
<th>Operator 2</th>
<th>Operator 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 1</td>
<td>.25</td>
<td>.20</td>
<td>.27</td>
</tr>
<tr>
<td>Part 2</td>
<td>.10</td>
<td>.15</td>
<td>.13</td>
</tr>
<tr>
<td>Part 3</td>
<td>.82</td>
<td>.90</td>
<td>.84</td>
</tr>
<tr>
<td>Part 4</td>
<td>.05</td>
<td>.21</td>
<td>.07</td>
</tr>
</tbody>
</table>

18. Considering only Part 1, single number estimates of \( \sigma^2_{R&R} \) and \( \sigma^2_{reproducibility} \) are closest to
a) \( .1824 \) and 0
b) \( .1824 \) and .0013
c) \( .1824 \) and .1824
d) .4271 and 0
e) .4271 and .0361

19. Still considering only Part 1, 95% confidence limits for the difference in long run fractions of "defective" calls that would be made by operators 1 and 2 (i.e. \( p_{11} - p_{12} \)) are \( .05 \pm .117 \)
    a) indicate that there is a detectable difference between how the operators perceive this part
    c) could be made narrower by increasing the number of "calls" the operators make on that part
d) Exacty 2 of responses a) through c) are correct completions of the sentence.
e) All of a) through c) are correct completions of the sentence.

20. Approximate 95% confidence limits for comparing the average (across many parts) fraction (across many calls) of "defective calls for operators 1 and 2 (operator 1 minus operator 2) are
a) \( -.06 \pm .067 \)
b) \( -.06 \pm .138 \)
c) \( -.06 \pm .276 \)
d) \( -.06 \pm .800 \)
e) None of the responses a) through d) above is close to a correct answer.