

**IE 361 Exam 1
Fall 2009**

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. A two-part definition of "quality" that includes both "quality of design" and "quality of conformance"
 - a) recognizes the roles of both product features/appropriateness *and* adherence to the engineering specifications established for the product.
 - b) applies to both manufacturing and service contexts.
 - c) can be thought of as an amplification of a "fitness for use" definition of quality.
 - 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.

2. The text's "6 Step Process Oriented Quality Assurance Cycle"
 - a) is one formalization of a rational/scientific/data-based approach to business process improvement.
 - b) is fundamentally opposed to most provisions of a corporate 6 Sigma program.
 - c) provides an intellectual framework and outline for many business improvement projects.
 - 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.

3. Regarding simple qualitative principles of practical industrial process data collection,
 - a) rational consideration of what sample size is appropriate involves assessment of both the variability one expects to encounter and the size of effect one hopes to be able to "see."
 - b) the advent of large corporate data bases means that in most cases, all information necessary for guiding process improvement efforts can simply be queried from existing sources.
 - c) the advent of modern digital measuring technology has removed the human element from industrial data collection and guarantees the collection of useful data.
 - 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.

For Problems 4 through 6, consider a situation in which small plastic bottles are filled with a dry spice and sold by weight of net contents. Net contents have a nominal value of 116 g. Bottle net contents weight can be measured with negligible bias and standard deviation σ_{device} , and measurement errors are normal.

4. If $\sigma_{\text{device}} = 1$ g, a single actual net contents level, x , must be at a minimum *how much*, if the bottle is to be 90% sure of being measured as containing at least 116 g (the label weight)?
 - a) at least 114.35 g .
 - b) at least 114.72 g .
 - c) at least 116 g .
 - d) at least 117.28 g .
 - e) at least 117.65 g .

5. Reducing the value of σ_{device} (improving measurement precision)
 - a) would reduce the correct answer to question 4.
 - b) would leave the correct answer to question 4 unchanged.
 - c) would increase the correct answer to question 4.
 - d) would change the correct answer to question 4, but *how* can not be determined without knowing the new value.

6. The bottle filling process has its own inherent variability, measured by σ_x . Suppose that the spice company ships only bottles with net contents measured as at least 116 g and wants at most .1% of filled bottles to fail a weighing test. This requires setting the mean fill level, μ_x , appropriately. (Note that increasing μ_x increases company costs.) Here
- decreasing either σ_{device} or σ_x decreases the required mean fill level.
 - decreasing either σ_{device} or σ_x increases the required mean fill level.
 - decreasing σ_{device} decreases the required mean fill level while decreasing σ_x increases it.
 - decreasing σ_{device} increases the required mean fill level while decreasing σ_x decreases it.
 - none of the answers a) through d) is correct.

Problems 7-12 concern measurement of the widths of some mass-produced binder clips using a vernier micrometer. **Fact: The upper 2.5% point of the $F_{6,6}$ distribution is about 5.82.**

7. Two different operators measure the same clip $n_1 = n_2 = 7$ times each, with resulting means and standard deviations $\bar{y}_1 = 31.9487$ mm, $\bar{y}_2 = 31.9280$ mm, $s_1 = .0055$ mm, and $s_2 = .0043$ mm. Based on 95% confidence limits, one can conclude
- that there is no clear difference in either operator biases or precisions.
 - that there is no clear difference in operator biases, but there is a clear difference in operator precisions.
 - that there is a clear difference in operator biases, but no clear difference in operator precisions.
 - that there are clear differences in both operator biases and in operator precisions.
 - nothing about comparison of operator biases or precisions from this information.

8. In the context of question 7

- a clear difference between operator biases is reproducibility variation.
- a clear difference between operator precisions is repeatability variation.
- one can be sure that the operator with the best precision has the smaller bias.
- none of responses a) through c) are correct completions of the sentence.
- exactly 2 of the responses a) through c) are correct completion of the sentence.

9. Two different operators measure the same 3 clips once each, with the results below.

	Operator 3	Operator 4
Clip 2	32.002 mm	31.947 mm
Clip 3	31.914 mm	31.899 mm
Clip 4	31.963 mm	31.928 mm

Assuming measurement linearity, 95% confidence limits for the difference in biases for these 2 operators are

- $.0350 \text{ mm} \pm 4.303 \frac{.0200}{\sqrt{3}} \text{ mm}.$
- $.0350 \text{ mm} \pm 4.303 \sqrt{\frac{.00194}{3} + \frac{.00058}{3}} \text{ mm}.$
- are $.0350 \text{ mm} \pm 4.303(.0200) \text{ mm}.$
- possible to determine from the given information, but are not given in any of responses a) through c).
- impossible to determine from the given information.

10. In the context of question 9, Operator 4 measured another clip (Clip 5) 10 times. The measurements obtained had sample standard deviation .0100 mm. Approximate 95% confidence limits for a clip-to-clip standard deviation of actual width
- are .0098 mm to .6957 mm.
 - are .0108 mm to .7644 mm.
 - are .0000⁺ mm to .0220 mm.
 - are .0000⁺ mm to .0242 mm.
 - None of responses a) through d) is close to a correct completion of the sentence.

11. Below is part of a JMP report from the analysis of the data of question 7, that one might treat as a very small Gauge R&R study involving only $I = 1$ part and $J = 2$ operators.

REML Variance Component Estimates						
Random Effect	Var Ratio	Var Component	Std Error	95% Lower	95% Upper	Pct of Total
Operator	8.6911764	0.0002111	0.0003034	-0.000384	0.0008058	89.681
Residual		2.4286e-5	9.9146e-6	1.2488e-5	6.6177e-5	10.319
Total		0.0002354				100.000

95% confidence limits for the reproducibility standard deviation

- are not available based on the given information.
- are 0 mm to .00081 mm.
- are 0 mm to .0284 mm.
- are .0000125 mm to .0000662 mm.
- are .0035 mm to .0081 mm.

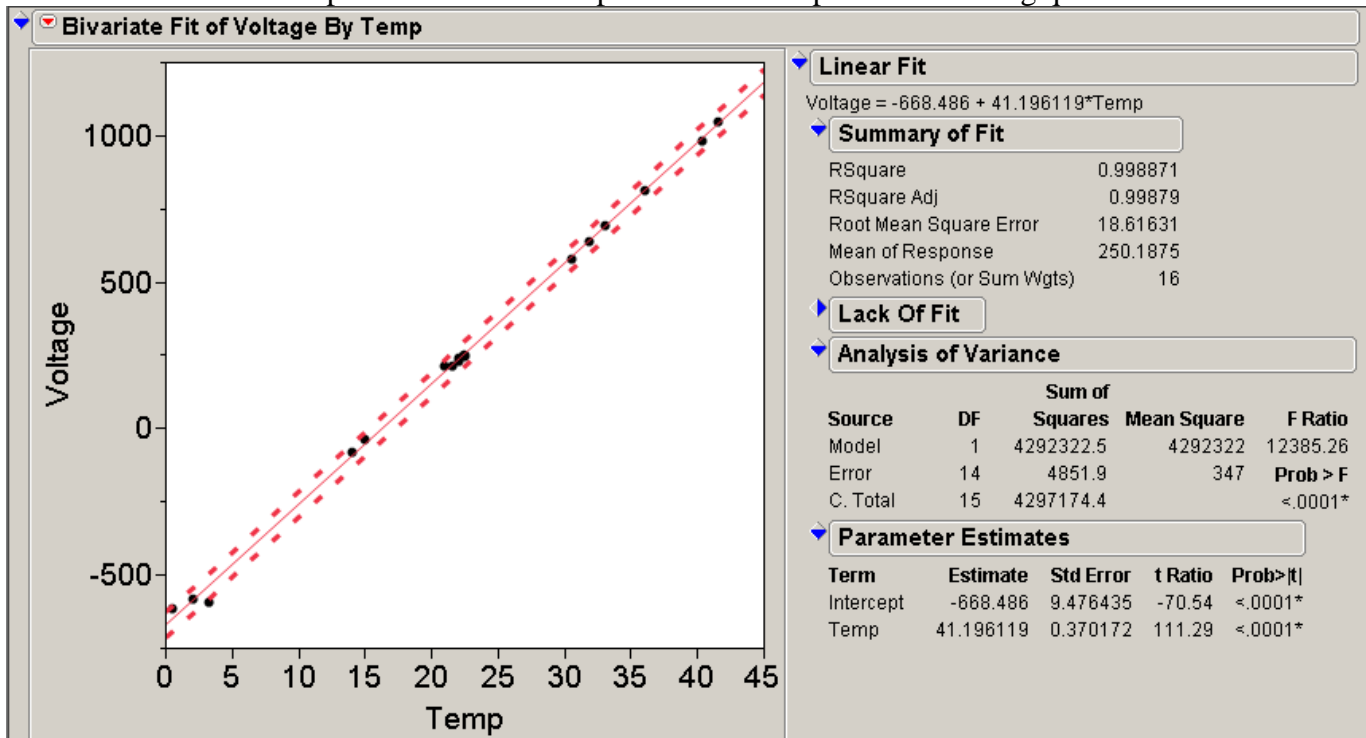
12. The analysis provided by the JMP report in question 11 suggests

- that one's best guess is that reproducibility variation is a bigger contributor to measurement imprecision than is repeatability variation.
- the precision with which one knows $\sigma_{\text{reproducibility}}$ and $\sigma_{\text{repeatability}}$ is poor enough that it is not possible to say definitively which is larger.
- that increasing I to the value 10 common on corporate gauge R&R forms should greatly improve the quality of one's information about $\sigma_{\text{reproducibility}}$.
- Responses a) and b) are the only correct completions of the sentence.
- Responses a) and c) are the only correct completions of the sentence.

Problems 13 through 15 concern an ANOVA analysis of a standard Gauge R&R data set obtained by using an optical gauge to measure a diameter for a certain injection molded plastic part. This study had $I = 5$, $J = 4$, and $m = 3$. Mean squares obtained were $MS_{\text{Operator}} = 6.66 \times 10^{-5} \text{ in}^2$, $MS_{\text{Part} \times \text{Operator}} = 1.33 \times 10^{-7} \text{ in}^2$ and $MSE = 1.4 \times 10^{-6} \text{ in}^2$. (As it turns out, these produce $\hat{\sigma}_{\text{reproducibility}} = .0020 \text{ in}$, $\hat{v}_{\text{reproducibility}} = 2.4$, $\hat{\sigma}_{\text{R\&R}} = .0023 \text{ in}$, and $\hat{v}_{\text{R\&R}} = 4.4$.) In fact, engineering specifications on the diameter in question were $.502 \text{ in} \pm .002 \text{ in}$.

13. 95% confidence limits for the repeatability standard deviation
- are impossible to determine here.
 - are $1.15 \times 10^{-6} \text{ in}^2$ to $1.791 \times 10^{-5} \text{ in}^2$.
 - are .0010 in to .0015 in .
 - are .0014 in to .0066 in .
 - None of responses a) through d) is a correct completion of the sentence.
14. Approximate 95% confidence limits for the reproducibility standard deviation
- should employ χ^2_2 percentage points, but the 2.4 value in the numerator under the root in the formula for confidence limits.
 - will be very widely separated because degrees of freedom will be small, following from the relatively small number of operators that were used in the study.
 - will be in the ratio of $\sqrt{7.378 / .051} = 12.03$ to 1.
 - All of the responses a) through c) are correct completions of the sentence.
 - Exactly 2 of the responses a) through c) are correct completions of the sentence.
15. 95% approximate confidence limits for the PTR (precision to tolerance ratio) or GCR here
- are impossible to determine from the information provided.
 - are about 2.1 to 9.9 and indicate that the measurement precision is not adequate for checking conformance to these specifications.
 - are about 2.1 to 9.9 and indicate that the measurement precision is adequate for checking conformance to these specifications.
 - are about 2.1 to 9.9 and because of the large difference between them prevent one from making definitive conclusions about the adequacy of the measurement precision.
 - None of the responses a) through d) is a correct completion of the sentence.

Below is part of a JMP report from the analysis of a calibration data set that was taken from an online MAE 334 Laboratory at the University of Buffalo. The lab concerns calibration of some thermocouples. Temperatures of cups of water, x , read from a dial thermometer and voltages, y , across the thermocouple were recorded in pairs. Use the report in answering questions 16 and 17.



x is in $^{\circ}\text{C}$, the units of y are μV , and the limits shown on the plot are 95% prediction limits.

16. 95% confidence limits for a repeatability standard deviation of voltages read on water of a fixed temperature are

- a) $13.6 \mu\text{V}$ to $29.4 \mu\text{V}$.
- b) $40.4 \mu\text{V}$ to $42.0 \mu\text{V}$.
- c) $-688.8 \mu\text{V}$ to $-648.2 \mu\text{V}$.
- d) impossible to determine from the given information.
- e) None of the responses a) through d) is a correct completion of the sentence.

17. Tomorrow this thermocouple will be used to measure temperature.

- a) If the voltage read on it is $0.0 \mu\text{V}$, one should estimate temperature to be 16.2°C .
- b) To the extent that one takes the dial thermometer as accurate, one may assume that today's temperatures obtained by converting voltages to temperatures have little bias.
- c) If the test leads used today to connect the thermocouple to the lab analyzer and collect the calibration data should disappear from the lab and need to be replaced tomorrow, the calibration work may need to be redone.
- d) Exactly 2 of responses a) through c) are correct.
- e) All 3 of responses a) through c) are correct.

The final step in the production of some glass vials is a visual inspection carried out by human inspectors. 4 particular vials (marked in an "invisible" ink that can be seen only under ultraviolet light) are repeatedly run through the inspection process among a large number of newly produced vials. Each of 2 company inspectors sees those vials 10 times in a company study. Below are the rates at which the vials are identified as defective by the inspectors

	Inspector 1	Inspector 2
Vial 1	.9	.8
Vial 2	1.0	1.0
Vial 3	.7	.8
Vial 4	.8	.6

18. In this context, differences between operators in the long run frequencies with which they call a particular vial defective

- a) are a kind of "reproducibility" variation.
- b) are reflected in values of \hat{p} that differ across a row.
- c) are only part of the variability in calls made across inspectors, as single inspectors are not completely consistent in how they call a given vial.
- 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.

19. Approximate 95% confidence limits for the difference in fractions of defective calls that the two operators would in the long run make on Vial 4 are

- a) $.2 \pm 1.96(.11)$.
- b) $.2 \pm 1.96(.20)$.
- c) $.2 \pm 1.96(.21)$.
- d) $.14 \pm 1.96(.21)$.
- e) given in none of the above responses a) through d).

20. Approximate 95% confidence limits for the difference in long run fractions of defective calls that the two operators would make across *all vials*

a) are $.05 \pm 3.182(.13)$.

b) are $.05 \pm 3.182(.06)$.

c) rely for their practical validity on the model assumption that the 4 vials are a random sample of the vials the inspectors will face.

d) Both a) and c) are correct completions of the sentence.

e) Both b) and c) are correct completions of the sentence.