

October 24, 2001

Prof. Vardeman

This exam consists of 18 multiple choice questions that will be scored at 5 points apiece. For each question select a *single best answer* and fill in the corresponding circle *on the Answer Sheet*. (No credit will be given if more than one circle is marked or if no circle is marked ... even if there is correct work on this paper.)

A series of measurement experiments were done using a single gage and can be summarized as follows:

I A single operator remeasured a single part $m = 15$ times, obtaining values with a sample mean of 5.252 inches and sample standard deviation of .002 inch.

II The operator from study I measured $n = 20$ other parts (once each) as they came off a production line one after another, obtaining values with a sample mean of 5.253 inches and a sample standard deviation of .004 inch.

III $J = 10$ other (different) operators each measured the same (additional) part once, obtaining values with a sample mean of 5.254 inches and a sample standard deviation of .003 inch.

Use the information from these measurement studies to answer questions 1-4.

1. What do you suggest as an estimate of "repeatability standard deviation" for this gage?
 - (a) .0020 inch
 - (b) .0030 inch
 - (c) .0035 inch
 - (d) .0040 inch
 - (e) not enough information is available to make an estimate
2. What do you suggest as an estimate of "R&R standard deviation" for this gage and population of operators?
 - (a) .0010 inch
 - (b) .0020 inch
 - (c) .0022 inch
 - (d) .0030 inch
 - (e) .0035 inch
3. What do you suggest as an estimate of "part-to-part" or "process" standard deviation in this context?
 - (a) .0020 inch
 - (b) .0022 inch
 - (c) .0030 inch
 - (d) .0035 inch
 - (e) .0040 inch
4. As it turns out, a standard error for the estimate of "part-to-part" or "process" standard deviation is about 23% of that estimate. Suppose that one judges this 23% to be "too large."
 - (a) This gage can not be used to check conformance to engineering tolerances, because this value shows the gage to be imprecise.
 - (b) This gage can not be used to check conformance to engineering tolerances, because this value shows the gage to be inaccurate.
 - (c) Larger sample sizes are needed in order to get a clear picture of the size of "part-to-part" variation.
 - (d) None of (a)-(c) is correct.
 - (e) Exactly two of (a)-(c) are correct.

5. "Calibration" of a gage or measurement system
- (a) concerns bringing the readings that it produces in line with the "truth."
 - (b) can only be accomplished through measurement of some items with both a "reference" or "standard" measurement system and with the gage or system of interest.
 - (c) can make use of regression analysis to produce "calibration curves" and confidence limits for reference measurements (based on observed values from the gage or system of interest).
 - (d) Exactly two of (a)-(c) are correct.
 - (e) All of (a)-(c) are correct.
6. Vardeman calls the ratio $6\sigma_{\text{measurement}}/(U - L)$ a "gage capability ratio." It is also known in some circles as a "precision to tolerance ratio." If your project client has a precision to tolerance ratio of about 1.0 for checking widget diameters
- (a) his or her production process is just barely capable of meeting specifications/engineering requirements on diameters.
 - (b) his or her gage isn't adequate to check conformance to the engineering specifications.
 - (c) his or her gage is just barely adequate to check conformance to the engineering specifications.
 - (d) Exactly two of (a)-(c) are correct.
 - (e) None of (a)-(c) are correct.

The table below gives process monitoring information on measured paint thickness (units are "mils") for a series of $r = 10$ hourly samples of $n = 3$ parts.

sample number	1	2	3	4	5	6	7	8	9	10	
\bar{x}	1.740	1.663	1.953	1.640	1.650	1.547	1.560	1.730	1.653	1.460	$\sum \bar{x} = 16.596$
R	.06	.03	.01	.05	.00	.03	.06	.07	.03	.02	$\sum R = .36$
s	.030	.015	.006	.027	.000	.015	.030	.036	.015	.010	$\sum s = .184$

The grand sample standard deviation of all 30 measurements summarized above is .130 mil. Use the table and this information to answer questions 7-10.

7. A retrospective upper control limit for R is:
- (a) .018
 - (b) .021
 - (c) .064
 - (d) .093
 - (e) .567
8. Retrospective control limits for \bar{x} based on ranges are:
- (a) $1.660 \pm .011$
 - (b) $1.660 \pm .036$
 - (c) $1.660 \pm .037$
 - (d) $1.660 \pm .130$
 - (e) $1.660 \pm .225$

9. Estimates of " σ " based on \overline{R} and on \overline{s} respectively are .0213 mil and .0208 mil. The grand sample standard deviation of all 30 measurements (.130 mil) is over 6 times these values.
- This difference suggests that in this problem, the .0213 mil and .0208 mil values are likely poor estimates.
 - This difference is consistent with the possibility the process mean was changing over the 10 hours of production.
 - This difference indicates very poor measurement precision for paint thickness.
 - Exactly two of (a)-(c) are correct.
 - All of (a)-(c) are correct.
10. Using more precise thickness measuring equipment in the future would (if n remains at 3)
- probably result in smaller upper control limits for R and s and control limits for \overline{x} that are placed closer to a center line than present ones.
 - decrease the "all-OK" ARL for a Shewhart \overline{x} chart.
 - degrade one's ability to detect process changes.
 - Exactly two of (a)-(c) are correct.
 - None of (a)-(c) are correct.

After some process improvement work, engineers decide that appropriate future standards for individual paint thickness values are $\mu = 1.500$ mils with $\sigma = .015$ mil, and they set engineering specifications at $1.500 \pm .050$ mils. They plan to do process monitoring using only \overline{x} 's based on samples of $n = 4$ parts (and using typical 3-sigma limits). Use these facts and an assumption that thicknesses are normally distributed as you answer questions 11 and 12.

11. With μ and σ at their standard values
- essentially all thickness values are inside specifications.
 - the ARL for the \overline{x} chart is about 370.
 - \overline{x} 's are normal, with mean 1.500 and standard deviation .0075 mil.
 - Exactly two of (a)-(c) are correct.
 - All of (a)-(c) are correct.
12. If the process parameter σ degrades to .030 mil (while μ remains at its standard value),
- essentially all thickness values are inside specifications.
 - the ARL for the \overline{x} chart is about 7.5.
 - since μ is unchanged, the \overline{x} chart will behave exactly as if there had been no process deterioration.
 - Exactly two of (a)-(c) are correct.
 - None of (a)-(c) are correct.
13. The percentage impurity in a powdered product is going to be monitored at a chemical plant. The "standard" value for this impurity rate is 1% by weight. Appropriate control limits for future impurity rates (expressed in fractional terms) found in 100 ml samples of this material
- are $.01 \pm 3\sqrt{(.01)(.99)}$
 - are $.01 \pm 3\sqrt{.01}$
 - are $.01 \pm 3\sqrt{(.01)(.99)/100}$
 - are $.01 \pm 3\sqrt{(.01)/100}$
 - can not be determined from the information given, as this is neither a p -chart nor a u -chart problem.

14. SPC and EFC are
- (a) competing technologies.
 - (b) both aimed at optimal on-line process adjustment/knob turning.
 - (c) both useful as variability reduction tools in manufacturing contexts.
 - (d) Exactly two of (a)-(c) are correct.
 - (e) None of (a)-(c) are correct.
15. Points plotting outside 3-sigma control limits on a Shewhart chart
- (a) signal the need for intervention or investigation of the cause of a process change.
 - (b) always indicate degradation in process performance.
 - (c) are the only kind of pattern that is ever used to signal the need for intervention.
 - (d) Exactly two of (a)-(c) are correct.
 - (e) None of (a)-(c) are correct.
16. Two hourly samples, the first of size $n_1 = 100$ and the second of size $n_2 = 200$ produce sample fractions nonconforming $\hat{p}_1 = .05$ and $\hat{p}_2 = .02$. If one assumes that the process producing the items was physically stable during the day when these samples were taken, a pooled estimate of the probability that any item produced was nonconforming is
- (a) .02
 - (b) .03
 - (c) .04
 - (d) .05
 - (e) .07
17. R charts
- (a) are easier to explain to a non-quantitative person than s charts.
 - (b) require less in the way of arithmetic (for "by hand" implementation) than s charts.
 - (c) have the force of historical momentum behind them (in comparison to s charts).
 - (d) All of (a)-(c) are correct.
 - (e) None of (a)-(c) are correct.
18. In quality assurance contexts, bimodal histograms
- (a) are called "Pareto diagrams."
 - (b) are preferable to mound-shaped ones, as they indicate that variation is minimal.
 - (c) suggest that there are two versions of some process element (and thus an assignable cause of variation).
 - (d) are useful because they show time trends in the data they summarize.
 - (e) None of (a)-(d) are correct.

Blacken the circle for EXACTLY ONE answer for each question.

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

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1. Multivariate control charts
 - a) always provide for simultaneous monitoring of several variables, but offer advantages over several "separate" control charts only when relationships between variables are important.
 - b) require "automatic" calculation in order to be practical tools for real application.
 - c) are always simple to interpret. When a point plots outside control limits, it is immediately obvious *what* about the sample it summarizes is "unusual."
 - d) Exactly two of a)-c) are correct.
 - e) All of a)-c) are correct.

2. Two critical dimensions, x_1 and x_2 , are measured on a large sample of (good/functional) machined metal parts of a certain kind. These dimensions are found to have respective sample means 1.001 inch and 1.002 inch and sample correlation $r = .6$. In rough terms, a multivariate control chart for x_1 and x_2 should then produce an out-of-control signal
 - a) if \bar{x}_1 is "too far" from 1.001 or \bar{x}_2 is "too far" from 1.002.
 - b) if \bar{x}_1 is "somewhat above" 1.001 while \bar{x}_2 is "somewhat above" 1.002.
 - c) if \bar{x}_1 is "somewhat above" 1.001 while \bar{x}_2 is "somewhat below" 1.002.
 - d) Both a) and b) are correct.
 - e) Both a) and c) are correct.

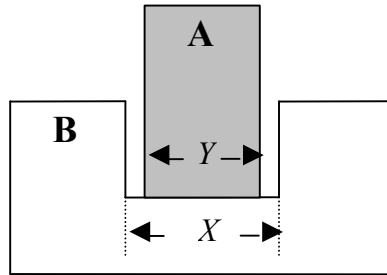
In a process monitoring problem, the only "rational subgroup"/sample size available is $n = 1$. A sequence of 10 successive single observations on the process is:

1.8, 3.6, 3.6, 4.5, 8.2, 6.1, .4, 2.8, 2.2, .7

3. The best possible estimate of the process "short term standard deviation" \mathbf{s}
 - a) is 2.410
 - b) is 2.078
 - c) is 1.842
 - d) would be the same, regardless of the order in which the values above were observed.
 - e) Exactly two of a)-d) are correct.

4. If one takes the process "short term standard deviation" \mathbf{s} to be 2.0 and uses 3.39 as a sensible retrospective "center line" for charting individual values, the observations above
 - a) show no evidence of process instability since they all are inside limits 3.39 ± 6 .
 - b) show no evidence of process instability since \bar{x} is inside limits $3.39 \pm 6/\sqrt{10}$.
 - c) show evidence of process instability since some are outside limits $3.39 \pm 6/\sqrt{10}$.
 - d) should be compared to engineering specifications in order to assess process stability.
 - e) None of a)-d) are correct.

Steel Block A is to sit in a machined slot in Block B as portrayed below. Blocks A and B are mass-produced by different suppliers. Randomly selected parts of the two types are subsequently assembled. We may thus think of dimensions X and Y as independent random variables.



Suppose that X has standard deviation .02 mm and that Y has standard deviation .02 mm.

5. The clearance $C = X - Y$ has what standard deviation?
 - a) .000 mm
 - b) .020 mm
 - c) .028 mm
 - d) .040 mm
 - e) .085 mm

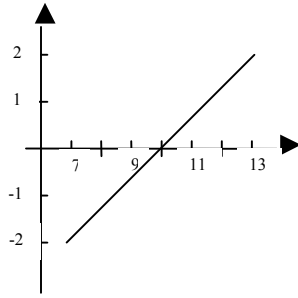
6. Suppose that it is easy to measure Y and the clearance $C = X - Y$ (but is perhaps difficult to measure X). I might do multivariate process monitoring of assemblies measuring Y and C . I should expect to use a "standard" correlation between Y and C that is
 - a) 0, since the assembly is done "at random."
 - b) positive, since on average C increases with Y .
 - c) negative, since on average C decreases with Y .
 - d) impossible to predict, since the assembly is done at random.
 - e) larger than 1 in absolute value.

For an assembly similar to the one above, specifications on the clearance are $.040 \pm .010$ mm. Suppose that a sample of $n = 30$ assemblies has average clearance $\bar{c} = .005$ and standard deviation of clearance $s_c = .003$ mm.

7. The sketchy information supplied above suggests that the machining equipment
 - a) at the two suppliers, if properly adjusted for mean dimensions, is sufficiently precise to produce nearly all clearances conforming to engineering specifications.
 - b) at the two suppliers is clearly not sufficiently precise to produce nearly all clearances conforming to engineering specifications.
 - c) of at least one of the suppliers should be adjusted to produce a different mean (for x or y).
 - d) Both a) and c) are correct.
 - e) Both b) and c) are correct.

8. 95% normal distribution two-sided prediction limits for a single additional clearance from the current (machining and assembly) process are
 - a) $.005 \pm .006$ mm
 - b) $.005 \pm .003$ mm
 - c) $.005 \pm .001$ mm
 - d) $.040 \pm .010$ mm
 - e) $.040 \pm .003$ mm

9. Below is a schematic of a reasonably linear-looking normal plot. The vertical axis is “standard normal quantile” and on the horizontal axis is “data quantile.”



The data mean and standard deviation are respectively

- a) 7 and 6
 - b) 10 and 6
 - c) 10 and 3
 - d) 10 and 1.5
 - e) 10 and .7
10. Normal plots of data from a stable process
- a) allow one to assess whether it is sensible to use standard (normal distribution-based) statistical formulas.
 - b) can indicate “in what ways” a distribution departs from a normal/bell-shape
 - c) can provide graphical estimates of process parameters (mean and standard deviation).
 - d) Exactly two of a)-c) are correct.
 - e) All of a)-c) are correct.

I judge a certain painting process to be physically stable and a sample of $n = 10$ measured paint thickness values it produces are

0.2, 0.8, 4.1, 2.4, 9.7, 9.5, 4.4, 6.2, 5.9, 1.8

11. If I may assume that paint thickness is normally distributed, an limits that that I am 95% sure contain 99% of thickness values are
- a) 4.5 ± 7.95
 - b) 4.5 ± 11.42
 - c) 4.5 ± 14.38
 - d) 4.5 ± 14.86
 - e) 4.5 ± 15.52
12. If I can't assume paint thickness is normally distributed
- a) I may use 0.2 and 1.8 as 82% prediction limits for an additional measured thickness and as 26% tolerance limits for 90% of paint thicknesses.
 - b) I may use 0.2 and 9.7 as 82% prediction limits for an additional measured thickness and as 26% tolerance limits for 90% of paint thicknesses.
 - c) it is possible to make prediction limits, but not tolerance limits.
 - d) it is possible to make tolerance limits, but not prediction limits.
 - e) there is no way to make either prediction or tolerance limits.
13. The ratio of an upper confidence limit for a process capability $6s$ to a lower confidence limit for the quantity can be taken as a measure of how much one can learn about it from a given size sample. For a sample of size $n = 30$ and 95% confidence, this ratio indicates that $6s$ can be estimated to within a factor of
- a) 1.55
 - b) 1.67
 - c) 1.69
 - d) 2.85
 - e) There isn't enough information given to answer this question. One must have a value for s .

14. As a goal for process performance, “Six Sigma” is “ $C_{pk} \geq 2$ ” or “process mean six standard deviations away from the closest specification.” “Six Sigma” propaganda also implies this is somehow equivalent to “3.4 parts per million defective.” If there is an equivalence, it must
- be based on a normal distribution assumption (about very extreme tails of the process distribution).
 - be guaranteed to hold by the central limit theorem and the fact that \bar{x} is normal.
 - be a secret mystery understood only by properly initiated six sigma “black belts.”
 - Both a) and b) are correct.
 - None of a)-c) are correct.
15. Participation in the Baldrige Award competition, pursuit of ISO 9000 registration and adoption of a Six Sigma program
- are all means of organizing a corporate business-process improvement effort.
 - all require substantial investment of corporate energy, resources and attention.
 - will all typically be reported as great successes by consultants that sell advice concerning them and by executives who invest their reputations and company resources in them.
 - are all potentially genuinely useful when well done and are all capable of absorbing resources far beyond anything they return in real benefits to a company when badly done.
 - All of a)-d) are correct.
16. The “house of quality”
- is a tool of “quality function deployment.”
 - is primarily useful on the factory floor during manufacturing.
 - is meant to help people think about relationships between end-customer requirements for a product and engineered features of the product.
 - Exactly two of a)-c) are correct.
 - All of a)-c) are correct.
17. “Robust design” popularized by Genichi Taguchi has to do with
- making products and processes insensitive to variability in their normal use environments.
 - making products and processes insensitive to variability in the components used to make them.
 - applying multi-factor experimentation to learn how to design products and processes to be insensitive to variations of environment and components.
 - All of a)-c) are correct.
 - None of a)-c) are correct.
18. The Baldrige Award competition and ISO 9000 registration
- are both administered by government agencies or consortiums of such agencies.
 - are both intended to address the entirety of how a company does business.
 - are both limited to the manufacturing sector.
 - Exactly two of a)-c) are true.
 - All of a)-c) are true.

December 20, 2001

Prof. Vardeman

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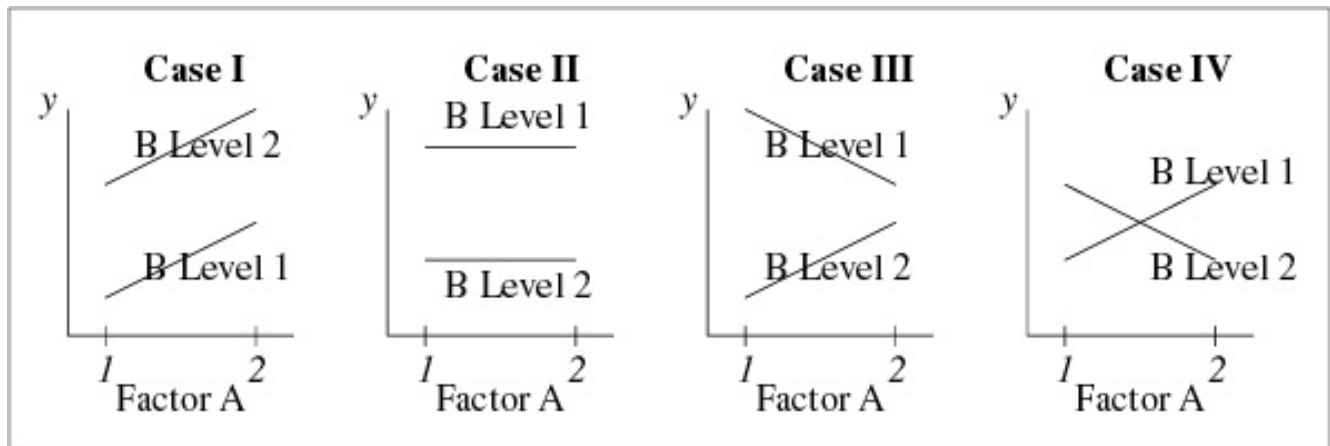
Tests of the effectiveness of $r = 5$ different operator's cab air filtration systems (meant to protect agricultural workers operating large mobile pesticide spraying machines) produced ratios y of outside-cab-particle-counts to inside-cab-particle-counts with summary statistics below. (Large ratios y are good.)

Design #1	Design #2	Design #3	Design #4	Design #5
$n_1 = 3$	$n_2 = 2$	$n_3 = 1$	$n_4 = 3$	$n_5 = 4$
$\bar{y}_1 = 50$	$\bar{y}_2 = 40$	$\bar{y}_3 = 65$	$\bar{y}_4 = 35$	$\bar{y}_5 = 55$
$s_1 = 7.2$	$s_2 = 6.5$		$s_4 = 5.0$	$s_5 = 7.5$

- Assume that variation in the ratios y can be described by a single standard deviation appropriate for any fixed design. An estimate of that standard deviation useful in making confidence intervals for linear combinations of means is
 - 6.45.
 - 6.55.
 - 6.62.
 - 6.68.
 - 6.75.
- Roughly speaking, any of the answers to problem 1 suggest that each sample mean in the table is "good to within about ____" as representing its "population" mean.
 - ± 6.8
 - ± 13.6
 - $\pm 6.8/\sqrt{n_i}$
 - $\pm 13.6/\sqrt{n_i}$
 - $\pm 13.6/\sqrt{13}$
- Suppose that Design #1 is the current design and the others represent potential changes. There might be interest in comparing the other designs to Design #1. On the basis of 95% two-sided confidence limits for differences in mean y (computed using any of the answers to problem 1, right or wrong),
 - neither Design #3 nor Design #4 differs detectably from Design #1.
 - Design #3 differs detectably from Design #1, but Design #4 does not.
 - Design #4 differs detectably from Design #1, but Design #3 does not.
 - both Design #3 and Design #4 differ detectably from Design #1.
 - Not enough information is given to compare Designs #3 and #4 to Design #1.

4. Suppose that new Designs #2 and #4 use filters supplied by Company X and Designs #3 and #5 use filters supplied by Company Y. An "L" that might be used to compare the performance of the two filter companies
- is $\frac{1}{2}(m_2 + m_4) - \frac{1}{2}(m_3 + m_5)$.
 - is $m_1 - \frac{1}{4}(m_2 + m_3 + m_4 + m_5)$.
 - is $\frac{1}{2}(m_2 - m_4) - \frac{1}{2}(m_3 - m_5)$.
 - can not be estimated since $n_3 = 1$.
 - Answer d) and exactly one of answers a) through c) are correct.
5. The numbers in the table above for a given design might summarize multiple measurements on a single prototype or summarize individual measurements on several prototypes.
- Which situation led to the numbers in the table really makes no difference in terms of the practical implications of confidence intervals for "L"s.
 - In terms of ultimately correctly choosing the best design for future production, multiple measurements on a single prototype per design is the preferable scenario.
 - "Multiple measurements on a single prototype for each design" is probably cheaper to obtain than "single measurements on multiple prototypes per design."
 - Exactly 2 of answers a) through c) are correct.
 - None of answers a) through c) are correct.
6. Suppose now that Designs #2 and #3 use one large fan and Designs #4 and #5 use two smaller fans. Then as regards the factors "A-Filter Company" and "B-Number of Fans" the *sizes* of the fitted effects are in the order
- A Main Effects larger than A × B Interactions larger than B Main effects
 - A × B Interactions larger than A Main effects larger than B Main Effects
 - A × B Interactions larger than A Main effects larger than B Main Effects
 - B Main Effects larger than A Main Effects larger than A × B Interactions
 - A Main Effects larger than B Main Effects larger than A × B Interactions
7. You have the responsibility of planning some additional data collection in this air filtration problem and must choose how to allocate a few more observations. Bearing in mind the data summaries in the table above and the goals of the study, your priorities for additional data collection should be (in decreasing order of importance)
- Design #3, Design #2, Design #4
 - Design #3, Design #1, Design #5
 - Design #5, Design #1, Design #2
 - Design #4, Design #2, Design #5
 - Design #4, Design #2, Design #1

Use the following set of 4 interaction plots to answer questions 8 through 11.



8. If we take each of the 4 plots as representing a different 2×2 factorial, which plot shows "Non-zero A Main Effects"?
 - a) Case I
 - b) Case II
 - c) Case III
 - d) Case IV
 - e) None of the plots shows non-zero A Main effects.

9. If we presume that the vertical scales are identical on the 4 plots, and assume that the plots represent different 2×2 factorials, the signs of b_2 as one goes left to right from Case I to Case IV are
 - a) +, -, -, -
 - b) +, -, -, 0
 - c) +, -, -, +
 - d) None of answers a) through d) are correct.
 - e) Not enough information is given to decide whether any of answers a) through d) are correct.

10. If we presume that the vertical scales are identical on the plots, and assume that Case I and Case II represent levels 1 and 2 of Factor C in a $2 \times 2 \times 2$ factorial, that 3-way factorial has
 - a) Non-zero A Main Effects.
 - b) Non-zero B Main Effects.
 - c) Non-zero C Main Effects.
 - d) Exactly two of answers a) through c) are correct.
 - e) None of answers a) through c) are correct.

11. If we presume that the vertical scales are identical on the plots, and assume that Case I and Case II represent levels 1 and 2 of Factor C in a $2 \times 2 \times 2$ factorial, that 3-way factorial
 - a) has zero 3-Factor Interactions.
 - b) has zero $A \times B$ 2-Factor Interactions.
 - c) Neither answer a) nor answer b) is correct.
 - d) Both answer a) and answer b) are correct.
 - e) Not enough information is given to decide whether any of answers a) through d) are correct.

An analysis of a 2^4 full factorial experiment (with factors A,B,C and D) leads to the conclusion that $a_2 = 4$, $ac_{22} = 2$ and $d_2 = -5$ all represent detectable effects (while the other types of effects are not detectable based on the data in hand).

12. A correct qualitative interpretation of these results includes:
 - a) Factor B is "inert," having no effect on response y either alone or in combination with other factors.
 - b) Factor D acts on response y "separate from" or "independent of" the other factors.
 - c) The impact of Factor C on response y depends upon the level of Factor A.
 - d) Exactly two of answers a) through c) are correct.
 - e) All of answers a) through c) are correct.

13. If the object of experimentation is to find a combination of levels of the 4 factors making the mean response as small as possible, the experimental results suggest using
 - a) A high, B high, C high, D high
 - b) A high, B high, C low, D high
 - c) A low, B low, C high, D high
 - d) A low, B low, C low, D high
 - e) None of the above combinations in a) through d) has minimum predicted response.

14. The 4-Factor interactions of A,B,C and D are "not detectable."
 - a) One is relieved about this since such "high order effects" are largely uninterpretable anyway.
 - b) This probably means either that a confidence interval for $abgd_{2222}$ includes 0 or that $abcd_{2222}$ doesn't "stand out" on a normal plot of the last 15 values produced by the Yates algorithm.
 - c) This strongly suggests that something has been overlooked in the data analysis and additional experimentation is needed.
 - d) Exactly two of answers a) through c) are correct.
 - e) All of answers a) through c) are correct.

15. When considering the possibility of 2^{p-q} fractional factorial experimentation, one needs to know that
 - a) the larger the value of q , the more definitive the experimental results are likely to be.
 - b) the methodology is more a tool for "factor screening" (making educated guesses at which factors are completely unimportant) than for final modeling of how response depends upon the experimental factors.
 - c) to be fully effective, it should never include any replication.
 - d) Exactly two of the answers a) through c) are correct.
 - e) None of the answers a) through c) are correct.

A process engineer plans a 2^{5-2} fractional factorial study (in the factors A,B,C,D and E). He chooses generators $D \leftarrow \rightarrow AB$ and $E \leftarrow \rightarrow AC$.

16. With this choice of generators, what effects will be aliased with the E Main Effect?
 - a) only the AC 2-factor interaction
 - b) only the AC 2-factor interaction and the ABDE 4-factor interaction
 - c) only the AC 2-factor interaction, the ABDE 4-factor interaction and the BCD 3-factor interaction
 - d) the AC 2-factor interaction, the ABDE 4-factor interaction, the BCD 3-factor interaction and four other factorial effects
 - e) None of answers a) through d) is correct.

17. With this choice of generators, what levels of Factors D and E will be used with the "A high, B low and C high" combination of the "first" 3 factors when data are collected?
 - a) D low and E low
 - b) D low and E high
 - c) D high and E low
 - d) D high and E high
 - e) It is impossible to determine this from the information supplied.

18. After listing the 8 sample means \bar{y} in Yates order as regards factors A,B and C and using the (3-cycle) Yates algorithm, by far the largest fitted sums of effects (except that average on the first line) is on the 6th line of the table of Yates additions and subtractions. The simplest possible interpretation of this outcome is
 - a) that the A Main Effect is important.
 - b) that the B Main Effect is important.
 - c) that the C Main Effect is important.
 - d) that the D Main Effect is important.
 - e) that the E Main Effect is important.