Black Belt Test Questions w/Answers:

1. Sigma refers to a roman letter that mathematicians use when discussing "average" or "mean"

   [ ] True [X] False

2. A process operating at 6 Sigma will only generate 3.4 defects per million opportunities?

   [X] True [ ] False

3. In order to achieve Six Sigma, practitioners follow a standard & rigorous methodology known as **DMAIC**

4. Six Sigma originated in the 1980's at Motorola?

   [X] True [ ] False

5. To achieve Six Sigma the DMAIC methodology follows which approach

   [ ] Brainstorm possible factors then randomly analyze them to find the significant ones

   [ ] Use SME knowledge & experience to quickly find solutions

   [X] Use the transfer function Y=f(x)

6. A Six Sigma process will only produce this many defects per million opportunities **3.4**

7. Achieving Six Sigma has nothing to do with meeting customer expectations?

   [ ] True [X] False

8. Who is credited as being the father of Six Sigma?

   [ ] Bob Galvin [ ] Mikel Harry

   [ ] Jack Welch [X] Bill Smith

9. Hard costs and soft costs are two types of COPQ

[X] True [ ] False

10. COPQ is an acronym that stands for what? **Cost of Poor Quality**

11. Which of the following is the one that is not part of the 7 deadly Muda?

[ ] Defects [ ] Over Production

[ ] Inventory [ ] Waiting

[ ] Movement [ ] Conveyance

[ ] Over Processing [X] Measuring

12. The Pareto Principle is named after an Italian economist Vilfredo Pareto

[X] True [ ] False

13. CTQ's are translated from VOC

[X] True [ ] False

14. CTQ is an acronym that stands for what? **Critical to Quality**

15. DPU is calculated by dividing the number of defects by the number of units

[X] True [ ] False

16. In Six Sigma Primary and Secondary Metrics are Mandatory

[X] True [ ] False

17. RTY is an acronym that stands for what? **Rolled Throughput Yield**

18. DPU is an acronym that stands for what? **Defects per Unit**

19. DMPO is an acronym that stands for what? **Defects per Million Opportunites**

20. Which of these is not one of the 4 stages of team development?

[ ] Performing [ ] Storming

[ ] Norming [ ] Forming

[X] Adorning

21. Which is not a characteristic of a successful team?

[ ] Common goals and working together to achieve that goal

[ ] Team member diversity (skills, knowledge, experience etc.)

[ ] Appropriate resources are available

[ ] Mutual respect

[ ] A good leader exists among the team

[X] Complacency exists

22. The **Primary** metric is your critical measure, it's the reason for your project, it's your beacon. This metric is the single most important thing to understand in order for you to be successful.

23. A well written problem statement contains all of the following except

[ ] Baseline [ ] Goal

[ ] Gap [ ] COPQ

[ ] Timeline Reference [X] Project Plan

24. From the following, select those that are characteristics of a Lean Enterprise

[X] Pull Systems [X] Flow

[X] Zero Waste [X] Availability

[X] Flexibility [X] Value Add

25. Put these 5S's into the proper order of execution

[**2**] Set in Order
[**1**] Sort
[**3**] Shine
[**5**] Sustain
[**4**] Standardize

26. Lean and Six Sigma are Both focused on Quality & Value for the customer?

[**X**] True [ ] False

27. What is the Japanese word for waste? **Muda**

28. What type of muda is waste from working more than required, scheduling more capacity than necessary or using resources that are overkill?

[ ] Inventory
[ ] Over-Production
[ ] Motion
[ ] Waiting
[ ] Transportation
[**X**] Over-Processing

29. **Defects** are flaws, errors or other non-conformities that compromise the value of a product

30. Lean is only about removing waste from the enterprise?

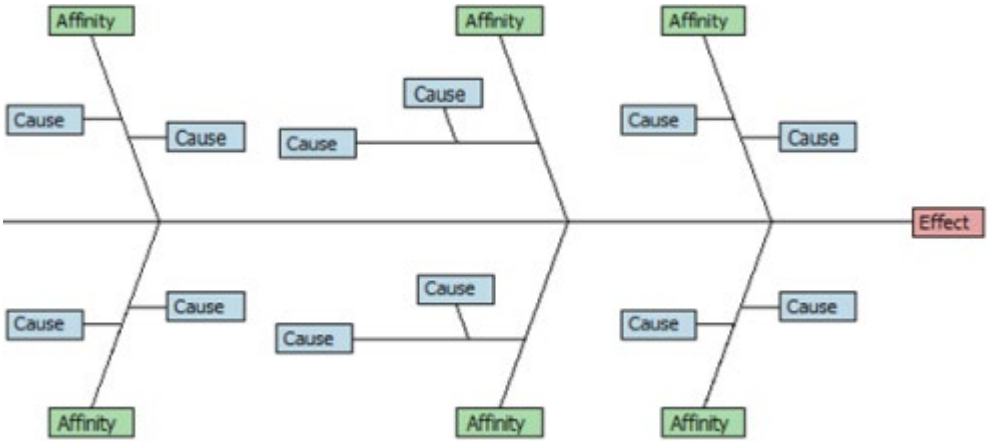
[ ] True [**X**] False

31. The 5 Principals of Lean are paraphrased below, select the correct 5

[**X**] Customer Defines Value
[**X**] Identify the Value Stream
[**X**] Continuous Flow
[**X**] Pull Where Possible
[**X**] Manage Toward Perfection
[ ] Batch Processing
[ ] Work Faster

32. **Over Production** is when more products are produced than are required by the next function or customer.

33. What is this?



[ ] FMEA [X] C&E Diagram

[ ] Process Map [ ] XY Diagram

34. Arrange these C&E process steps into the correct order of execution.

[3] Affinitize or group the causes

[2] Brainstorm all potentials causes

[4] Evaluate

[1] Identify & define the effect

35. SIPOC is an acronym using which words?

[X] Suppliers [ ] Immediate

[X] Inputs [X] Process

[X] Outputs [X] Customers

[ ] Primary [ ] Secondary

36. A SIPOC is another name for a flow chart

[ ] True [X] False

37. An FMEA ranks potential failures using values assigned to severity, occurrence and detection?

[X] True [ ] False

38. Which of these tools might you use if you want to develop a Risk Priority Number and ranking for the various types of failures that could occur?

[ ] Cause & Effect Diagram [ ] SIPOC

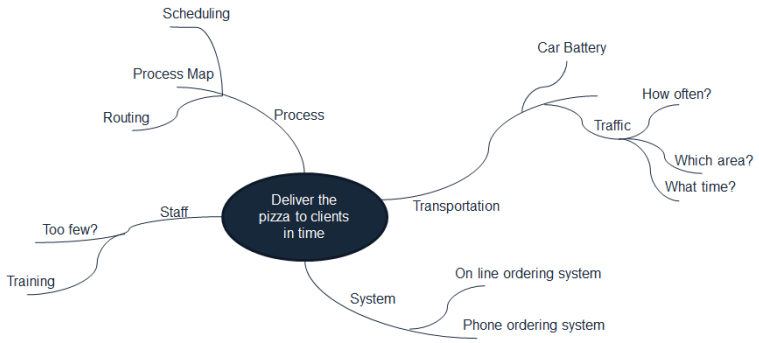
[ ] Functional Process Map [ ] Thought Process Map

[ ] XY Diagram [X] FMEA

39. **SIPOC** should be used when trying to understand the links between customers, process steps and process outputs.

40. **Cause & Effect Diagram** should be used when brainstorming possible causes to an effect.

41. What is this?



[ ] FMEA [ ] C&E Diagram

[ ] Process Map [ ] SIPOC

[X] Thought Process Map [ ] Spaghetti Map

42. Continuous variables are measured, Discrete variables are counted

[X] True [ ] False

43. Nominal Data are discrete and rank ordered.

[ ] True [X] False

44. Median is the average of a set of data

[ ] True [X] False

45. Median is the middle value in a set of data

[X] True [ ] False

46. Mode is the value in a data set that occurs most frequently

[X] True [ ] False

47. Standard Deviation is a measure that describes how far the data points spread away from the mean

[X] True [ ] False

48. For the normal distribution, about **68%** of the data fall within +/- 1 standard deviation

49. For the normal distribution, about **95%** of the data fall within +/- 2 standard deviation from the mean?

50. A **Histogram** is a graphical tool to present the distribution of the data

51. The null hypothesis for a normality test is that the data are normally distributed?

[X] True [ ] False

52. Select only those that are examples of graphical analysis tools

[X] Box Plots [X] Histograms

[X] Scatter Plots [X] Run Charts

[ ] ANOVA table [ ] Regression Equation

53. Measurement Systems Analysis is a step in a Six Sigma project that ensures the data are reliable and trustworthy before making any data-based decisions.

[X] True [ ] False

54. Repeatability evaluates whether the same appraiser can obtain the same value multiple times when measuring the same object using the same equipment under the same environment.

[X] True [ ] False

55. Which are common sources of variation in most measurement systems?

[X] Part to part variation [X] Measurement instrument

[X] Repeatability [X] Reproducibility

[ ] Humidity [ ] Altitude

56. In a Measurement Systems Analysis, which source of variation do we hope to see be the greatest?

[X] Part to part variation [ ] Measurement instrument

[ ] Measurer (person measuring) [ ] Altitude

[ ] Humidity

57. **Bias** is the difference between the observed value and the true value of a measurement.

58. **Reproducibility** evaluates whether different appraisers can obtain the same value when measuring the same object independently.

59. In a Variable Gage R&R, the acceptable % contribution of variation attributable to Repeatability and Reproducibility should be less than **10%**

60. If Kappa is greater than 0.7 the measurement system is acceptable

[X] True [ ] False

61. Cp considers the within-subgroup standard deviation and Pp considers the total standard deviation from the sample data.

[X] True [ ] False

62. Being stable does not guarantee a process to be capable. However, being stable is a prerequisite to determine whether a process is capable.

[X] True [ ] False

63. Cpk measures the process's potential capability to meet the two-sided specifications. It doesn't take the process average into consideration.

[ ] True [X] False

64. Cp, and Pp take both the variation and the average of the process into consideration when measuring the process capability.

[ ] True [X] False

65. A Pp of greater than 1 suggests...

[ ] Total process variation is greater than the width between the USL and LSL

[X] Total process variation is less than the width between the USL and LSL

66. A Pp of less than 1 suggests...

[X] Total process variation is greater than the width between the USL and LSL

[ ] Total process variation is less than the width between the USL and LSL

67. Which of the following measurements is NOT a process capability index?

[ ] Cp [ ] Cpk

[X] Kappa [ ] Percent Defectives

68. The **Multi-vari** chart is used to visualize sources of variation.

69. Pick which of the following are basic features of the data that a probability distribution describe?

[X] Shape [X] Center

[X] Scale [ ] Stability

70. Which distribution has mean equal to np and the variance equal to np(1-p)?

[X] Binomial [ ] Normal

[ ] Exponential [ ] Weibull

71. Which continuous probability distribution is the basis for the analysis of variance or test for equal variances?

[ ] Normal Distribution [X] F Distribution

[ ] Student t distribution [ ] Chi Square Distribution

72. Select only continuous distributions from the list below.

[X] Normal Distribution [X] F Distribution

[X] Student T Distribution [ ] Binomial Distribution

[ ] Poisson Distribution

73. 68-95-99.7 Rule for Normal Distribution states that

- about 68% of the data stay within σ from the mean.
- about 95% of the data stay within 2σ from the mean.
- about 99.7% of the data stay within 3σ from the mean

[X] True [ ] False

74. The process of selecting a subset of observations within a population is referred to as **Sampling**.

75. Statistical inference is the process of making inferences regarding the characteristics of an unobservable population based on the characteristics of an observable **Sample**.

76. To reduce β risk, we should increase the **Power**.

77. The higher the confidence level, the wider the confidence interval?

[**X**] True [ ] False

78. The larger the sample size, the wider the confidence interval?

[ ] True [**X**] False

79. A valid sample must be unbiased and representative of the population?

[**X**] True [ ] False

80. The more variability, the tighter the confidence interval?

[ ] True [**X**] False

81. Which sampling strategy is used to select samples at regular intervals based on a ordered list where items in the population are arranged in some order?

[ ] Simple random sampling [ ] Stratified sampling

[**X**] Systematic sampling [ ] Cluster sampling

82. A Population is grouped into distinct and independent categories and then samples are randomly or systematically selected in each category of the population. Which sampling strategy is this?

[ ] Simple random sampling [**X**] Stratified sampling

[ ] Systematic sampling [ ] Cluster sampling

83. A hypothesis test is a statistical method in which a specific hypothesis is formulated about the population, and the decision of whether to reject the hypothesis is made based on sample data.

[X] True [ ] False

84. When the p-value is **less** than the α level, we reject the null and claim that there is a statistically significant difference between different groups.

85. α risk is the risk of making a Type I error?

[X] True [ ] False

86. The proportion of the area under the sampling distribution and beyond the test statistic is the **p-value**.

87. α risk is the risk of being wrong if you fail to reject the null?

[ ] True [X] False

88. In which of the following conditions can we not reject the null hypothesis?

[ ] the test statistic falls into the critical region

[ ] the test statistic is greater than the critical value

[ ] P-value is smaller than alpha level

[X] P-value is greater than alpha level

89. One-tailed hypothesis test is used when we care about whether there is a difference between groups and we don't care about the direction of the difference.

[ ] True [X] False

90. Select the two possible conclusions of hypothesis testing

[ ] Accept the Alternative Hypothesis [X] Reject the Null Hypothesis

[X] Fail to Reject the Null Hypothesis [ ] Reject the Alternative Hypothesis

91. When p-value is higher than the α level, we fail to reject the null and claim that there is no statistically significant difference between different groups.

[X] True [ ] False

92. One sample t-test is a hypothesis test to study whether there is a statistically significant difference between a population mean and a specified value.

[X] True [ ] False

93. A **2 Sample-t test** is a hypothesis test to study whether there is a statistically significant difference between the means of two populations

94. Which of these is not an assumption of the ANOVA?

[X] The data of k populations are discrete

[ ] The data of k populations are continuous.

[ ] The data of k populations are normally distributed

[ ] The variances of k populations are equal.

95. If the p-value of a t test is 0.6656 and the alpha level is 0.05 then we _____ the null hypothesis and we claim that the means of two groups are _____ .

[X] fail to reject [ ] reject

[X] equal [ ] unequal

96. In a Two Sample T-test If |tcalc|>tcrit, we reject the null and claim there is a statistically significant difference between the means of the two populations.

[X] True [ ] False

97. The One-way ANOVA (one-way analysis of variance) is a statistical method to compare means of two or more populations.

[X] True [ ] False

98. Which of these is not one of the three types of two sample t-tests?

[ ] Two Sample T-test unknown variances

[ ] Two Sample T-test known variances; equal variances

[ ] Two Sample T-test known variances; un-equal variances

[X] Two Sample T-test known variances; variances greater than 1

99. ANOVA compares the means of different groups by analyzing the averages between and within groups.

[ ] True [X] False

100. The Mann-Whitney test is a statistical hypothesis test to compare the medians of two populations which are normally distributed?

[ ] True [X] False

101. The **Kruskal-Wallis** test is a one-way analysis of variance hypothesis test to compare the medians among more than two groups.

102. Mood's median is an alternative to Kruskal-Wallis?

[X] True [ ] False

103. Which of these is not a true statement?

[ ] For the data with outliers, Mood's median test is more robust than Kruskal-Wallis

[ ] Mood's median is an alternative to Kruskal-Wallis.

[ ] Mood's median test is used to compare the medians of two or more populations

[X] Mood's median test is not robust for non-normally distributed populations.

104. Select all that are accurate statements.

[X] One sample sign tests are hypothesis tests comparing medians to a specified value

[X] the one Sample sign test is an alternative test to the parametric one sample t test

[X] One sample sign test is a distribution-free test.

105. The difference between the One Sample Sign test and the One Sample Wilcoxon test is that the One Sample Wilcoxon assumes the distribution of the data is symmetric.

[X] True [ ] False

106. Chi-square test can be used to test whether there is any statistically significant relationship between two discrete factors?

[X] True [ ] False

107. Correlation analysis helps us to understand the direction and degree of association between variables. It also suggests causation or the cause of the relationship between variables.

[ ] True [X] False

108. It is possible that two variables have a perfect non-linear relationship when the correlation coefficient is low.

[X] True [ ] False

109. Correlation implies causation.

[ ] True [X] False

110. R^2 (also called coefficient of determination) measures the proportion of variability in the data which can be explained by the model.

[X] True [ ] False

111. R^2 ranges from 0 to 1. The higher R^2 is, the better the model can fit the actual data.

[X] True [ ] False

112. Residuals are the vertical difference between actual values and the predicted values or the "fitted line" created by the regression model.

[X] True [ ] False

113. Which of these statements is incorrect?

[ ] Simple Linear Regression is a statistical technique to fit a straight line through the data points.

[ ] Simple Linear Regression models the quantitative relationship between two variables.

[ ] Simple Linear Regression describes how one variable changes according to the change of another variable.

[X] Simple Linear Regression uses at least two predictor variables.

114. The **Residual** in a regression model is the difference between the actual Y and the fitted Y.

115. The difference between Simple Linear Regression and Multiple Linear Regression

- Simple Linear Regression only has one predictor.
- Multiple Linear Regression has two or more predictors.

[X] True [ ] False

116. Multicollinearity is a situation where two or more independent variables in a multiple regression model are correlated with each other?

[X] True [ ] False

117. To detect multicollinearity and quantify its severity in a regression model we use a measure called **Variance Inflation Factor**.

118. Which of these is not a recommended way to deal with multicollinearity?

[ ] Increase the sample size

[ ] Collect samples with a broader range for some predictors

[ ] Remove the variable with high multicollinearity and high p-value

[ ] Remove variables that are included more than once

[X] Remove the variable with low multicollinearity and low p-value

119. Select three types of valid logistic regression models

[X] Binary [X] Ordinal

[X] Nominal [ ] Tertiary

120. From the following, select those that are good indicators of a valid multiple regression model

[X] Rsquare Adj > 0.80 [X] All variables VIF < 5

[X] Regression model p-value < 0.05 [X] Residuals normally distributed with mean near 0

[X] Residuals are independent [X] All variables p-value < 0.05

121. Your multiple regression model returned 3 variables that were significant and the model looks good based on all other measures. Of the 3 variables, the one with the **highest** coefficient has the most influence on your "Y".

122. The following assumptions should be met to ensure the reliability of any simple or multiple linear regression model:

- The errors are normally distributed with mean equal to zero.
- The errors are independent.
- The errors have a constant variance.
- The underlying population relationship is linear.

[X] True [ ] False

123. Residuals are the vertical difference between actual values and the predicted values or the "fitted line" created by the regression model.

[X] True [ ] False

124. True or False, An experiment is a scientific exercise to gather data to test a hypothesis, theory or previous result?

[X] True [ ] False

125. True or False, Experiments are planned studies in that they are prepared such that data is collected actively and purposefully?

[X] True [ ] False

126. True or False, Experiment factors should have largely been determined through with the tools and analytics used throughout the DMAIC process?

[X] True [ ] False

127. True or False, a properly planned and run DOE will create waste and defective products because treatment combinations "test" boundaries.

[X] True [ ] False

128. Why use experiments?

[X] Solve Problems [X] Prove a Hypothesis

[X] Optimize Performance [ ] Random Trouble-Shooting

129. OFAT is a traditional form of planned experimentation and learning, what does OFAT stands for?

One Factor at a Time

130. Factor levels are the selected settings of a factor we are testing in the experiment

[X] True [ ] False

131. The most popular DOE is a two-level design meaning there are only two levels for each factor

[X] True [ ] False

132. A treatment is a combination of different factors at different level settings

[X] True [ ] False

133. An interaction effect is the average change in the response variable resulting from changes in the levels of one factor

[ ] True [X] False

134. Interaction effect is the average change in the response resulting from the change in the interaction of multiple factors

[X] True [ ] False

135. If one of the factors or interactions in your DOE has a p-value larger than alpha level (0.05), it indicates that the particular factor or interaction does not have statistically significant impact on the response?

[X] True [ ] False

136. In a full factorial DOE with 3 factors and two levels, how many treatment combinations should there be?

[ ] 3^2 = 9 treatments [X] 2^3 = 8 treatments

[ ] 2x3 = 6 treatments

137. In a full factorial DOE with 3 factors and two levels and one replicate, how many runs will there be?

[ ] (3^2) x 2 = 18 runs [X] (2^3) x 2 = 16 runs

[ ] (2 x 3) x 2 = 12 runs

138. **Replicates** are the number of times running an individual treatment is repeated

139. Fractional factorials use more treatment combinations or runs than full factorials?

[ ] True [X] False

140. Fractional factorial experiments are intentionally designed with fewer runs or treatment combinations?

[X] True [ ] False

141. Fractional factorial experiments are intentionally designed with fewer runs or treatment combinations but have the same number of inputs; this causes confounding or aliasing?

[X] True [ ] False

142. When two input factors are aliases with each other, the effects they each have on the response can easily be separated and determined?

[ ] True [X] False

143. Fractional factorials are less able to determine effects because of fewer degrees of freedom available to evaluate higher order interactions?

[X] True [ ] False

144. In a 1/2 fraction DOE with 3 factors and two levels, how many experimental runs will there be?

[ ] 3^2/2 = 4.5 runs [X] 2^3/2 = 4 runs

[ ] 2x3/2 = 3 runs

145. In a 1/4 fraction DOE with 8 factors and two levels, how many experimental runs will there be?

[ ] 256 [ ] 128

[X] 64

146. **Resolution** is the quantification or degree of confounding

147. 5S is systematic method to organize, order, clean, and standardize a workplace…and keep it that way?

[X] True [ ] False

148. Kanban system is a demand driven system

[X] True [ ] False

149. An example of a detective type of Poka Yoke is when your car makes an audible "ding" or alarm when your passenger has not buckled their seat belt?

[X] True [ ] False

150. An example of a preventive type of Poka Yoke is when your dishwasher will not start without the door closed?

[X] True [ ] False

151. The term "poka-yoke" in Japanese means "signboard"

[ ] True [X] False

152. A **Kanban** system is a "pull" production scheduling system to determine when to produce, what to produce and how much to produce based on the demand

153. This word in Japanese means "signboard" **Kanban**

154. Which if these is not a benefit of a Kanban system

[ ] Minimizes in-process inventory

[ ] Prevents overproduction

[ ] Improves responsiveness to dynamic demand

[X] Increases dependency on accurate demand forecasts

[ ] Streamlines the production flow

[ ] Visualizes the work flow

155. From the following, select those that are characteristics of a Lean Enterprise

[X] Pull Systems [X] Flow

[X] Zero Waste [X] Value Add

[ ] High Levels of Inventory [ ] Several Quality Control Teams

156. Statistical process control (SPC) is a statistical method to monitor the performance of a process using control charts in order to keep the process in statistical control?

[X] True [ ] False

157. Statistical process control can be used to distinguish between the special cause variation and the common cause variation in the process?

[X] True [ ] False

158. It is impossible to eliminate the special cause variation from a process?

[ ] True [X] False

159. Statistical process control can be used in different phases of six sigma projects

[X] True [ ] False

160. This control chart plots individual points on one graph and moving range points on another graph

[X] I-MR [ ] Xbar-R

[ ] Xbar-S [ ] EWMA

161. I chart is valid only if MR chart is in control

[X] True [ ] False

162. Xbar-R chart is a control chart for continuous data with a constant subgroup size between two and ten

[X] True [ ] False

163. U chart is a control chart monitoring the percentages of defectives

[ ] True [X] False

164. P chart is a control chart monitoring the average defects per unit

[ ] True [X] False

165. Test 1 of the Western Electric rules for SPC is when one point lands more than three standard deviations from the center line?

[X] True [ ] False

166. NP chart is a control chart monitoring the count of defectives

[X] True [ ] False

167. Return on investment is the ratio of net financial benefits (either gain or loss) on a project or investment to its financial costs

[X] True [ ] False

168. Net present value is the total present value of cash flows calculated using a discount rate?

[X] True [ ] False

169. **Control Plans** ensure that the changes introduced by a Six Sigma project are sustained over time

170. **Standard Operating Procedures** are documents that focus on process steps, activities and specific tasks required to complete an operation.

171. Which of these might not be considered a standard element of a control plan?

[ ] SOP (Standard Operating Procedures) [ ] Communication Plan

[ ] Training Plan [ ] Audit Plan

[X] Floor plan

172. Control plans typically include measurement systems that monitor and help manage key process performance?

[X] True [ ] False

173. Communication Plans are documents that focus on planning and preparing for the dissemination of information?

[X] True [ ] False

174. A response plan should be a component of as few control plan elements as possible

[ ] True [X] False

175. Which of the following might be used to ensure actions, processes, procedures and other tasks are performed as expected?

[X] Audit [X] Training

[X] SOP's [X] Communication

[X] Measurements [X] Poka-Yoke

Situational Question

The division you support has been producing units of a special product at one of its troubled facilities. Recently senior management has announced layoffs that have impacted operations so severely that immediate changes in processes are the only way the business can continue producing units. Your peers and supervisors have acted quickly to make the necessary changes and redesign the production & supply chain process to accommodate fewer employees. You have been pulled in to take on the responsibility of monitoring the quality of the units being produced to ensure that the process changes have not adversely affected quality. Fortunately you were anticipating this management action and you began collecting defect data 30 days ago.

A month has now passed since the process changes have been in effect. Below is the data you have been able to collect over the past 60 days. The first 30 data points were proactively collected by you prior to the layoff and the second 30 points are post layoff. Because you diligently studied your Six Sigma training materials, you were also savvy enough to make sure that all data points were randomly drawn from equal subgroup sizes that were properly stratified across shifts and other known production variations so you're confident in the data.

Your supervisors are now requesting an assessment of the quality data and have asked you to conduct the analysis and present it in the production review scheduled for this week. In preparation, use the data below to perform your analysis and answer the following questions:

Defects	Process Change
19	Before
23	Before
14	Before
18	Before
9	Before
22	Before
16	Before
12	Before
11	Before
19	Before
10	Before
19	Before
23	Before
14	Before
18	Before
9	Before
12	Before
14	Before
12	Before
19	Before
16	Before
14	Before
15	Before
13	Before
18	Before
17	Before
15	Before
12	Before
9	Before
12	Before
13	After
17	After
8	After
12	After
3	After
16	After
10	After
6	After
5	After
13	After
4	After
13	After
17	After
8	After
12	After
3	After
6	After
8	After
6	After
13	After
10	After
8	After
9	After
7	After
12	After
11	After
9	After
6	After
3	After
6	After

176. True or False, the process before the layoff (before process changes) was in control?

[X] True [ ] False

177. True or False, the process after the layoff (post process change) is not in control?

[ ] True [X] False

178. Given what you know of the situation, which of the following control charts should you use to determine process stability?

[ ] CumSum [ ] P chart

[ ] EWMA [X] IMR chart

179. True or False, the data is normally distributed for each parameter?

[X] True [ ] False

180. True or False, the parameters have equal variances?

[X] True [ ] False

181. True or False, in terms of defects, the process after the layoff has improved?

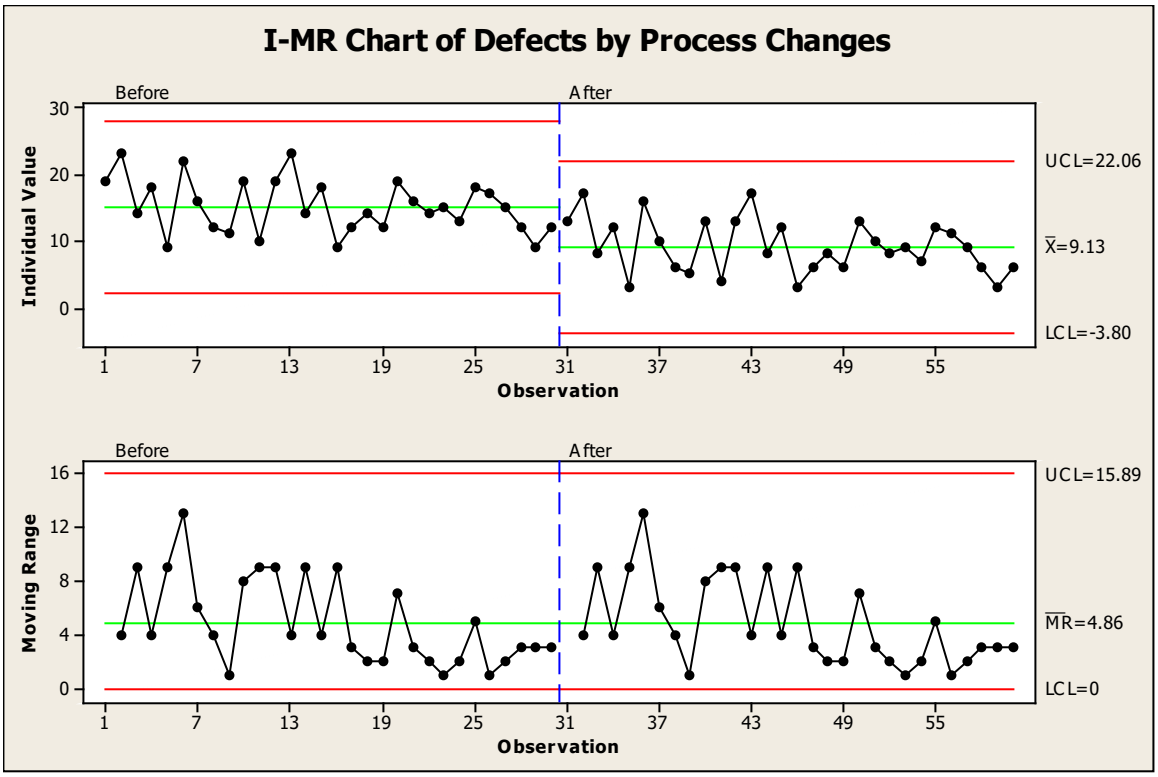
[X] True [ ] False

182. True or False, the p-value for a 2-sample t test between the before and after subgroups is greater than 0.05?

[ ] True [X] False

Situational Assessemnt Results & Interpretations:

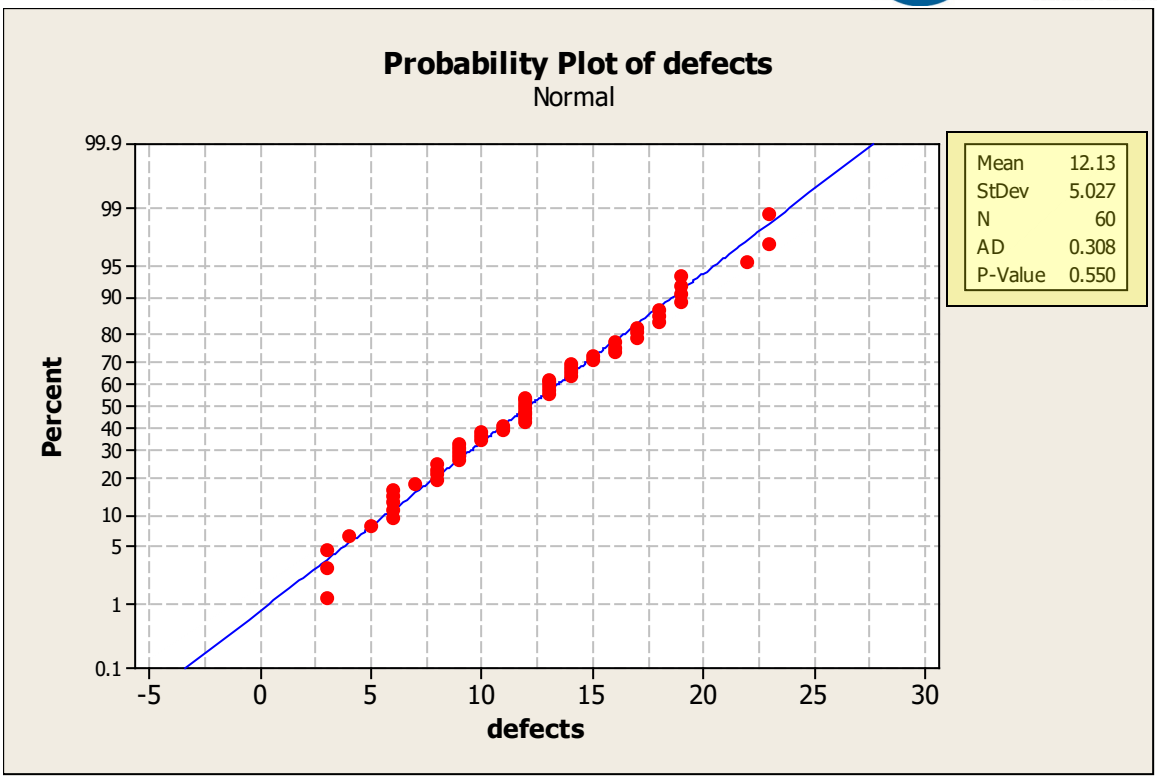
Given that the defect samples were randomly drawn from stratified subgroups of equal subgroup sizes and that the data were continuous and independent, the simplest and most effective control chart selection for this particular situation should be the IMR chart (one could argue that it should be the C chart but that chart is not in your curriculum). Below is the IMR chart output with control limits separately calculated for each parameter (process changes).



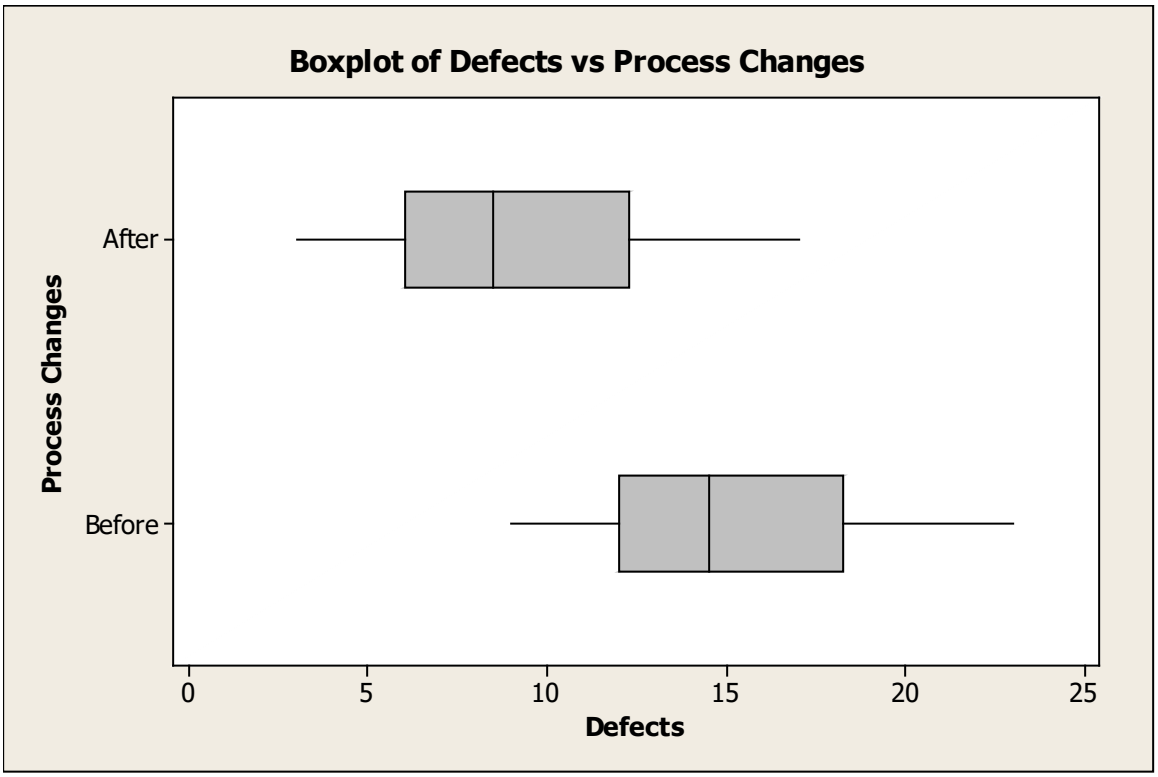
All tests were performed for this chart and there are no indications of out of control conditions. Both charts, the "I" chart (individuals) and "MR" chart (Moving Range) are stable and in control for each parameter. An interesting note however is that the layoff seemed to have improved the defect rate. Let's dig a little deeper and see if that's real…

Before jumping straight into a statistical comparison of the before and after data we need to validate a couple of key assumptions namely, normality and equal variances.

The probability plot below was performed to assess the normality of the data. The null hypothesis for a normality test is the data are normal. Therefore if the data are not normal we would have to reject the null. However, in order to reject the null our p-value should be below 0.05. The p-value for our test result is 0.55 which indicates that we can't reject the null and we must conclude that the data are normal.



Next we perform a test of equal variances.



Although the box plots appear to be from different populations, alone they are not enough to determine if variances are equal. Below is the statistical output for the test of equal variances.

Test and CI for Two Variances: Defects vs Process Changes

```
Method

Null hypothesis         Sigma(After) / Sigma(Before) = 1
Alternative hypothesis  Sigma(After) / Sigma(Before) not = 1
Significance level      Alpha = 0.05


Statistics

Process
Changes   N  StDev  Variance
After    30  4.049    16.395
Before   30  4.049    16.395

Ratio of standard deviations = 1.000
Ratio of variances = 1.000


95% Confidence Intervals

                                  CI for
Distribution   CI for StDev      Variance
of Data            Ratio           Ratio
Normal        (0.690, 1.449)  (0.476, 2.101)
Continuous    (0.693, 1.444)  (0.480, 2.085)

                                              Test
Method                          DF1  DF2  Statistic  P-Value
F Test (normal)                  29   29       1.00    1.000
Levene's Test (any continuous)    1   58       0.00    1.000
```

Knowing the data are normal, we should follow the output of the "F Test" to determine if variances are equal. The result is actually a perfect match with the p-value being 1.0. We can safely assume that two data sets have equal variances. Now let's look at the 2-Sample t test:

Two-Sample T-Test and CI: Defects, Process Changes

```
Process
Changes   N   Mean  StDev  SE Mean
After    30   9.13   4.05     0.74
Before   30  15.13   4.05     0.74

Difference = mu (After) - mu (Before)
Estimate for difference:  -6.00
95% CI for difference:  (-8.09, -3.91)
T-Test of difference = 0 (vs not =): T-Value = -5.74  P-Value = 0.000  DF = 58
Both use Pooled StDev = 4.0491
```

With the p-value of 0.000, it's well below the 0.05 thresh hold. We will reject the null which is that there is no difference. A p-value of zero clearly indicates that there is a difference between the means of the Before group and After group. If the p is low the null must go!.