QUESTIONS:

1. **You've just completed a gauge R&R study. The repeatability was analyzed to be 0.5679 standard deviations, and the reproducibility was analyzed to be 0.4231 standard deviation. What is the measurement system variation?**
   - 0.9910
   - 0.5679
   - 0.4231
   - 0.7082

2. **You're executing a gauge R&R using the Average and Range method where 3 operators are measuring 10 parts, 3 times each. The R-double bar of your measurements is 0.821. What is the repeatability of your measurement system?**
   - 0.485
   - 0.821
   - 0.906
   - 0.728

3. **You've just completed a gauge R&R study. The variance associated with the equipment variation was analyzed to be 0.1743, and the variance associated with the appraiser variation was analyzed to be 0.4231. What is the variance of the total measurement system?**
   - 0.7729
   - 0.5974
   - 0.4575
   - 0.4231

4. **You've just completed a gauge R&R study. The gauge R&R was analyzed to be 0.9246 standard deviations, and the part to part variation was analyzed to be 4.2134 standard deviations. What is the percent variation of the measurement system?**
   - 21.9%
   - 17.9%
   - 94.6%
   - 21.4%

5. **You've just completed a gauge R&R study. The gauge R&R was analyzed to be 0.5719 standard deviations, the appraiser variation was analyzed to be 0.3755 standard deviations and the total variation was analyzed to be 2.7061. What is the percent variation of the equipment variation?**
   - 13.2%
   - 5.3%
   - 21.1%
   - 15.9%

6. **You manufacture a widget and use an x-bar and R chart to monitor your process, where you sample 3 units in each subgroup, and R-bar = 16.0. Estimate the population standard deviation for this process.**
   - 16.0
   - 9.5
   - 27.1
   - 13.2

7. **You manufacture a widget and use an x-bar and S chart to monitor your process, where you sample 5 units in each subgroup, and s-bar = 4.2. Estimate the population standard deviation for this process.**
   - 4.2
   - 2.1
   - 3.9
   - 4.5

8. **Which of the following control charts is most sensitive to changes in the process?**
   - I-MR Chart
   - P Chart
   - C Chart
   - X-bar and R Chart

9. **You're executing a sampling scheme per ANSI/ASQ Z1.4 and during reduced sampling you observe that the actual number of non-conformances are below the reject number, but above the accept number. Which is the appropriate response to this situation?**
   - Reject the lot and continue with reduced sampling
   - Reject the lot and switch back to normal inspection
   - Accept the lot and continue with reduced sampling
   - Accept the lot and switch back to normal inspection

10. **A vendor has just shipped you 3,000 units which you intend to inspect per ANSI/ASQ Z1.4 using a Single Sampling Plan at the normal, general level II inspection level at an AQL of 0.25. What is the sample size you must take?**
    - 50
    - 80
    - 125
    - 200

11. How many treatments would be required for a DOE with 9 factors where a half factorial design is chosen?

- 512
- 256
- 128
- 64

12. Fill in the blank: A _____ design is used to study a process to determine which factors are critical and which are not.

- Screening/Characterization Design
- Modeling/Optimization Design
- Full Factorial Design
- Orthogonal Array

13. You've just completed a gauge R&R study on a measurement scale. The repeatability was analyzed to be 0.1275lbs^2, and the reproducibility was analyzed to be 0.3465lbs^2. What is the measurement system variation?

- 0.1362 lbs^2
- 0.4740 lbs^2
- 0.9457 lbs^2
- 0.6528 lbs^2

14. You're executing a gauge R&R using the Average and Range method where 2 operators are measuring 6 parts, 3 times each. The R-double bar of your measurements is 0.3215. What is the repeatability of your measurement system?

- 0.2850
- 0.1878
- 0.3215
- 0.2265

15. You've just completed a gauge R&R study. The repeatability was analyzed to be 0.7525 standard deviations, and the reproducibility was analyzed to be 1.2545 standard deviation. What is the measurement system variation?

- 2.1400
- 1.4628
- 2.0070
- 1.6823

SOLUTIONS:

1. **You've just completed a gauge R&R study. The repeatability was analyzed to be 0.5679 standard deviations, and the reproducibility was analyzed to be 0.4231 standard deviation. What is the measurement system variation?**
   - 0.9910
   - 0.5679
   - 0.4231
   - 0.7082

$$Measurement\ System\ Variation\ (GRR) = \sigma_{GRR} = \sqrt{(EV)^2 + (AV)^2}$$

$$\sigma_{GRR} = \sqrt{(0.5679)^2 + (0.4231)^2} = 0.7082$$

2. **You're executing a gauge R&R using the Average and Range method where 3 operators are measuring 10 parts, 3 times each. The R-double bar of your measurements is 0.821. What is the repeatability of your measurement system?**
   - 0.485
   - 0.821
   - 0.906
   - 0.728

$$Equipment\ Variation\ (EV) = \sigma_{Repeatability} = \frac{\bar{\bar{R}}}{d_2}$$

$$\sigma_{Repeatability} = \frac{\bar{\bar{R}}}{d_2} = \frac{0.821}{1.693} = 0.485$$

3. **You've just completed a gauge R&R study. The variance associated with the equipment variation was analyzed to be 0.1743, and the variance associated with the appraiser variation was analyzed to be 0.4231. What is the variance of the total measurement system?**
   - 0.7729
   - 0.5974
   - 0.4575
   - 0.4231

   The variance of the measurement system is simply the addition of repeatability plus reproducibility.

$$\sigma^2_{GR\&R} = \sigma^2_{Repeatability} + \sigma^2_{Reproducibility}$$

$$\sigma^2_{GR\&R} = 0.1743 + 0.4231 = 0.5974$$

4. You've just completed a gauge R&R study. The gauge R&R was analyzed to be 0.9246 standard deviations, and the part to part variation was analyzed to be 4.2134 standard deviations. What is the percent variation of the measurement system?

- 21.9%
- 17.9%
- 94.6%
- 21.4%

The percent variation is calculated as the measurement system variation divided by the total variation. The measurement system variation is known to be 0.9246 standard deviations.

$$\boldsymbol{Percent\ Variation = \frac{Measurement\ System\ Variation}{Total\ Variation}}$$

$$\boldsymbol{Measurement\ Variation = \sigma_{GR\&R} = 0.9246}$$

The total variation must be calculated using the equation above and is 4.3137 standard deviations.

$$\boldsymbol{Total\ Variation: \sigma^2_{Total\ Variation} = \sigma^2_{GR\&R} + \sigma^2_{Part\ To\ Part\ Variation}}$$

$$\boldsymbol{\sigma_{Total\ Variation} = \sqrt{\sigma^2_{GR\&R} + \sigma^2_{Part\ To\ Part\ Variation}} = \sqrt{(0.9246)^2 + (4.2134)^2} = 4.3137}$$

Now we can calculate the percent variation of the measurement system to be 21.4%.

$$\boldsymbol{Percent\ Variation = \frac{0.9246}{4.3137} = 21.4\%}$$

5. **You've just completed a gauge R&R study. The gauge R&R was analyzed to be 0.5719 standard deviations, the appraiser variation was analyzed to be 0.3755 standard deviations and the total variation was analyzed to be 2.7061. What is the percent variation of the equipment variation?**
   - 13.2%
   - 5.3%
   - 21.1%
   - **15.9%**

   First, we must determine the equipment variation using the gauge R&R and appraiser variation values, 0.5719 and 0.3755.

$$\boldsymbol{Measurement\ System\ Variation\ (GRR) = \sigma_{GRR} = \sqrt{(EV)^2 + (AV)^2}}$$

$$\boldsymbol{0.5719 = \sqrt{(EV)^2 + (0.3755)^2}}$$

Step #1 – Start by squaring both sides, which yields this equation

$$\boldsymbol{0.5719^2 = (EV)^2 + (0.3755)^2}$$

Step #2 – work out the squared values, which yields this result:

$$\boldsymbol{0.3271 = (EV)^2 + 0.14100}$$

Step #3 – Re-arrange the equation to look like this:

$$\boldsymbol{0.3271 - 0.1410 = (EV)^2 = 0.1861}$$

Step #4 – Take the square root of each side to solve for EV

$$\boldsymbol{EV = 0.4314}$$

Step #5 - Once the equipment variation is known, the percent variation can be calculated using the following equation:

$$\boldsymbol{Equipment\ Variation = \frac{Equipment\ Variation\ (Repeatability)}{Total\ Variation} = \frac{0.4314}{2.7061} = 15.9\%}$$

6. **You manufacture a widget and use an x-bar and R chart to monitor your process, where you sample 3 units in each subgroup, and R-bar = 16.0. Estimate the population standard deviation for this process.**
   - 16.0
   - **9.5**
   - 27.1
   - 13.2

   We divide R-bar by the factor d_2, which is based on the n=3 sample size.

$$\textbf{\textit{Population Standard Deviation}} = \hat{\sigma} = \frac{\bar{R}}{d_2} = \frac{16}{1.693} = 9.5$$

7. **You manufacture a widget and use an x-bar and S chart to monitor your process, where you sample units in each subgroup, and s-bar = 4.2. Estimate the population standard deviation for this process.**
   - 4.2
   - 2.1
   - 3.9
   - 4.5

   We divide S-bar by the factor c_4, which is based on the n=5 sample size.

$$\textbf{\textit{Population Standard Deviation}} = \hat{\sigma} = \frac{\bar{s}}{C_4} = \frac{4.2}{0.9400} = 4.5$$

8. **Which of the following control charts is most sensitive to changes in the process?**
   - I-MR Chart
   - P Chart
   - C Chart
   - **X-bar and R Chart**

9. **You're executing a sampling scheme per ANSI/ASQ Z1.4 and during reduced sampling you observe that the actual number of non-conformances are below the reject number, but above the accept number. Which is the appropriate response to this situation?**
   - Reject the lot and continue with reduced sampling
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   - Accept the lot and continue with reduced sampling
   - **Accept the lot and switch back to normal inspection**

10. A vendor has just shipped you 3,000 units which you intend to inspect per ANSI/ASQ Z1.4 using a Single Sampling Plan at the normal, general level II inspection level at an AQL of 0.25. What is the sample size you must take?

- 50
- 80
- 125
- **200**

Starting at the sample size code letter, for general inspection level II, at a total lot size of 3,000 the **code letter is K**.

When we go to the single normal inspection table, you can see **a down arrow** at the intersection of K and an AQL of 0.25.

This means we must use the sampling plan below K, which is the **sample size code letter L**. So, the sample size is 200 and the accept number (c) is 1.

11. How many treatments would be required for a DOE with 9 factors where a half factorial design is chosen:

- 512
- **256**
- 128
- 64

$$\boldsymbol{Half}\ Factorial\ Design\text{: }Number\ of\ Treatments = \frac{Levels^{Factors}}{2} = 2^{F-1} = 2^{9-1} = 256$$

12. Fill in the blank: A _____ design is used to study a process to determine which factors are critical and which are not.

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$$\sigma^2_{GR\&R} = \sigma^2_{Repeatability} + \sigma^2_{Reproducibility}$$

Notice how the repeatability and reproducibility is reported in the units of lbs^2. This means we're given the variance term of those factors. The answers are also in units of lbs^2, which again indicates that the answer is given in variance.

$$\sigma_{GRR} = 0.1275\ lbs^2 + 0.3465\ lbs^2 = 0.4740\ lbs^2$$

14. You're executing a gauge R&R using the Average and Range method where 2 operators are measuring 6 parts, 3 times each. The R-double bar of your measurements is 0.3215. What is the repeatability of your measurement system?

- 0.2850
- **0.1878**
- 0.3215
- 0.2265

$$Equipment\ Variation\ (EV) = \sigma_{Repeatability} = \frac{\bar{\bar{R}}}{d_2}$$

$$\sigma_{Repeatability} = \frac{\bar{\bar{R}}}{d_2} = \frac{0.3215}{1.712} = 0.1878$$

15. You've just completed a gauge R&R study. The repeatability was analyzed to be 0.7525 standard deviations, and the reproducibility was analyzed to be 1.2545 standard deviation. What is the measurement system variation?

- 2.1400
- **1.4628**
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$$Measurement\ System\ Variation\ (GRR) = \sigma_{GRR} = \sqrt{(EV)^2 + (AV)^2}$$

$$\sigma_{GRR} = \sqrt{(0.7525)^2 + (1.2545)^2} = \sqrt{2.1400} = 1.4628$$