QUESTIONS:

1. **Your process consumed raw material that was non-conforming, causing a change in the critical dimension. This an example of:**
   - Common Cause Variation
   - Special Cause Variation
   - A lack of process capability
   - An unstable, but capable process

2. **What factor determines which variable control chart should be used?**
   - Defects v. defectives
   - The accuracy of the measurement system being used
   - The acceptance sampling plan associated with your product
   - The number of units sampled within each subgroup

3. **A manufacturing inspector measures the length of a plastic part as it comes off the mold injection process. 7 plastic parts are measured per sub-group. Which of the following control charts is most appropriate to use for this process?**
   - P Chart
   - C Chart
   - X-bar and R chart
   - X-bar and S Chart

4. **Using the following data points from these 5 sub-groups, calculate R-bar.**
   - 2
   - 3
   - 4
   - 5

Sub-group	Sample 1	Sample 2	Sample 3
1	12	15	16
2	14	12	13
3	10	13	13
4	14	16	16
5	14	12	16

5. **You want to reduce the number of defects on the production floor. You want to collect data to determine which defects occur most often. Which tool should you use?**
   - Pareto Chart
   - Check Sheet
   - Flow Chart
   - Scatter Plot

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've been tasked with improving a process, and you've identified that variation in your equipment tooling is causing variation within your process that's resulting in yield loss. You're in the process of adding an alignment feature to your tooling to mistake-proof the process. Which phase of the DMAIC process are you in?**
   - Measure
   - Analyze
   - Improve
   - Control

8. **You're manufacturing a widget and using an X-bar and R chart to control the critical feature of the product. Your normal process has the following attributes: X-double bar is 225, R-bar is 12, n = 8. Identify the lower control limits for the X-bar chart.**
   - 220.52
   - 229.48
   - 233.14
   - 218.71

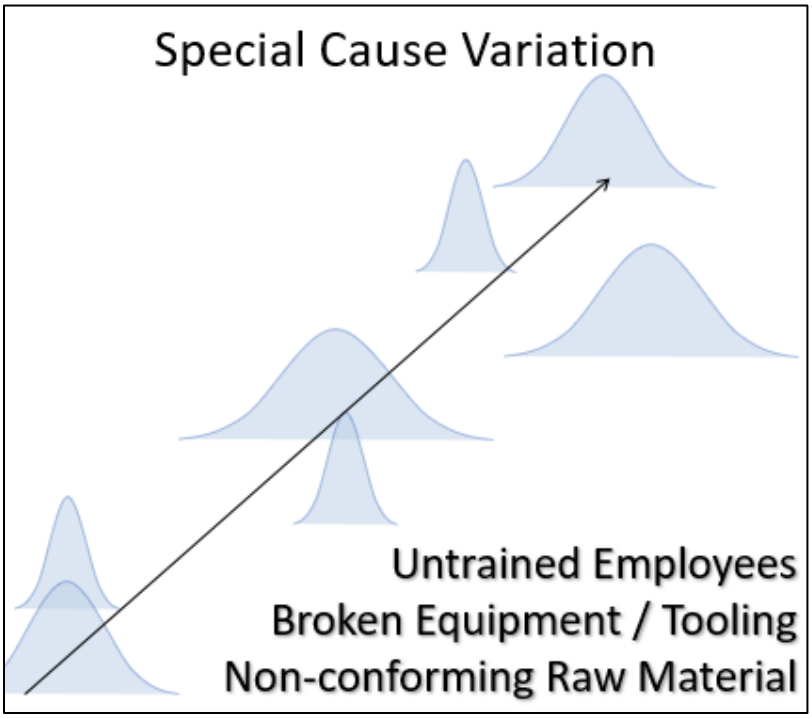
9. **You're running a series of experiments, and you confirm that the results of the first experiment does not affect the probabilities of the potential outcomes in the second experiment. How would you describe these experiments?**
   - Mutually Inclusive
   - Mutually Exclusive
   - Independent
   - Dependent

10. **You're manufacturing a widget and using an X-bar and R chart to control the critical feature of the product. Your normal process has the following attributes: X-double bar is 225, R-bar is 12, n = 8. Identify the upper control limits for the range chart.**
    - 5.73
    - 18.23
    - 22.37
    - 24.17

SOLUTIONS:

1. **Your process consumed raw material that was non-conforming, causing a change in the critical dimension. This an example of:**
   - Common Cause Variation
   - **Special Cause Variation**
   - A lack of process capability
   - An unstable, but capable process

   Non-Conforming Raw Material is an example of **special cause variation** in the process.

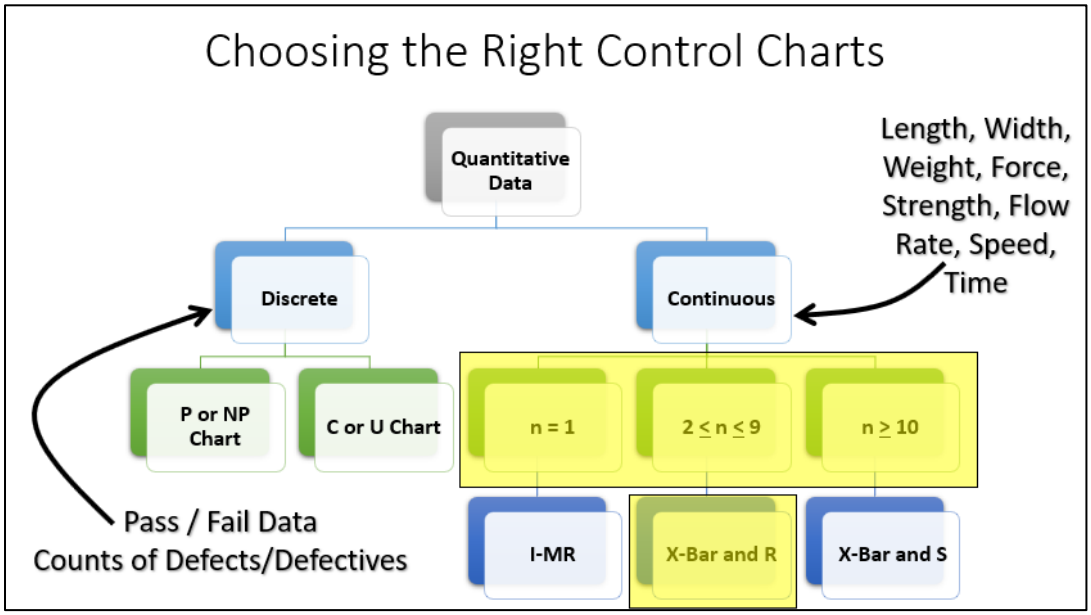


2. **What factor determines which variable control chart should be used?**
   - Defects v. defectives
   - The accuracy of the measurement system being used
   - The acceptance sampling plan associated with your product
   - **The number of units sampled within each subgroup**

   (See the picture in Q3's answer for more details.)

3. **A manufacturing inspector measures the length of a plastic part as it comes off the mold injection process. 7 plastic parts are measured per sub-group. Which of the following control charts is most appropriate to use for this process?**
   - P Chart
   - C Chart
   - **X-bar and R chart**
   - X-bar and S Chart

   The length of a plastic part is a **continuous** data type. Since the **sample size is n=7**, the appropriate control chart for this process would be **X-bar and R Chart**.



4. **Using the following data points from these 5 sub-groups, calculate R-bar.**
   - 2
   - **3**
   - 4
   - 5

Sub-group	Sample 1	Sample 2	Sample 3	Range
1	12	15	16	4
2	14	12	13	2
3	10	13	13	3
4	14	16	16	2
5	14	12	16	4
				3 R-Bar

   First, we must solve for the **Range** value for each sub-group, shown in the far-right hand column. (Range = Max. – Min.)

   Then we must take the average value of the 5 sub-group ranges to find the average range value of **3** (R-bar).

5. **You want to reduce the number of defects on the production floor. You want to collect data to determine which defects occur most often. Which tool should you use?**
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   - **Check Sheet**
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   - Scatter Plot

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.**
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   - **9.5**
   - 27.1
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X-Bar and R Chart				
Subgroup Sample Size	X-Bar Factor	Range Factors		Variance Factor
n	A_2	D_3	D_4	d_2
2	1.880	-	3.267	1.128
3	1.023	-	2.575	1.693
4	0.729	-	2.282	2.059
5	0.577	-	2.115	2.326
6	0.483	-	2.004	2.534
7	0.419	0.076	1.924	2.704
8	0.373	0.136	1.864	2.847
9	0.337	0.184	1.816	2.970
10	0.308	0.223	1.777	3.078
15	0.223	0.347	1.653	3.472
20	0.180	0.415	1.585	3.735
25	0.153	0.459	1.541	3.931

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

$$Population\ Standard\ Deviation = \hat{\sigma} = \frac{\bar{R}}{d_2}$$

$$\hat{\sigma} = \frac{\bar{R}}{d_2} = \frac{16}{1.693} = 9.5$$

7. **You've been tasked with improving a process, and you've identified that variation in your equipment tooling is causing variation within your process that's resulting in yield loss. You're in the process of adding an alignment feature to your tooling to mistake-proof the process. Which phase of the DMAIC process are you in?**
   - Measure
   - Analyze
   - **Improve**
   - Control

   In the **Improve** phase of **DMAIC** is when you would add ***mistake-proofing tools*** like alignment features to equipment to eliminate a source of variation.

8. **You're manufacturing a widget and using an X-bar and R chart to control the critical feature of the product. Your normal process has the following attributes: X-double bar is 225, R-bar is 12, n = 8. Identify the lower control limits for the X-bar chart.**
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X-Bar and R Chart				
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$$Lower\ Control\ Limit\ for\ \bar{X}:\ LCL_{\bar{X}} = \bar{\bar{X}} - A_2\bar{R}$$

The A2 constant for a subgroup sample size of 8 is 0.373.

$$\boldsymbol{LCL_{\bar{X}}} = \bar{\bar{X}} - A_2\bar{R} = 225 - 0.373 * 12 = \mathbf{220.52}$$

9. You're running a series of experiments, and you confirm that the results of the first experiment does not affect the probabilities of the potential outcomes in the second experiment. How would you describe these experiments?

- Mutually Inclusive
- Mutually Exclusive
- **Independent**
- Dependent

Two events are **independent** if the occurrence of one event does **NOT** change the probability of occurrence of the next event.

10. You're manufacturing a widget and using an X-bar and R chart to control the critical feature of the product. Your normal process has the following attributes: X-double bar is 225, R-bar is 12, n = 8. Identify the upper control limits for the range chart.

- 5.73
- 18.23
- **22.37**
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X-Bar and R Chart				
Subgroup Sample Size	X-Bar Factor	Range Factors		Variance Factor
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First, we must look up the constants required to calculate the upper control limits for the range chart using the sample size (n=8); we find $D_4 = 1.864$. Now we can calculate the upper control limits for the Range chart:

$$\boldsymbol{UCL_R} = D_4 * \bar{R} = 1.864 * 12 = \mathbf{22.37}$$