CQE Academy

CQE EXAM

Top 10 CQE Exam Topics

40 Questions for
the **Top 10 Topics**
of the **CQE Exam**

ANDY ROBERTSON

The Pareto Principle!!

To become a CQE, you have to be familiar with the Pareto Principle, or the **80/20 rule**.

This principle applies to the CQE Exam where **80% of exam questions come from the top 20% of topics.**

So, I decided to put together a list of the **Top 10 Topics that make up the majority of the CQE Exam**:

1. **Acceptance Sampling**
2. **Auditing**
3. **Lean Tools**
4. **Measurement System Analysis**
5. **Reliability and Maintainability**
6. **Risk Management**
7. **Statistical Decision Making**
8. **Statistical Process Control**
9. **The 7 QC Tools**
10. **The 7 Management and Planning Tools**

I've added links above to 4 topics where you can read and learn all about them over at CQE Academy.

Free Practice Exam

To help you assess how well you know these topics, I put together this free 40 question practice exam.

I've also added the solutions to these questions starting down on page 14.

Feedback!

Please enjoy the quiz, and send me any feedback at **Andy@CQEAcademy.com**.

Practice Exam for Top 10 Topics from CQEAcademy.com

1. **Fill in the blank: _____ is commonly defined as the worst tolerable process average that is still considered acceptable.**
   - AQL
   - LTPD
   - AOQ
   - AOQL

2. **Fill in the blank: _____is defined as any activity that consumes resources but creates no value for the customer.**
   - Muda
   - Muri
   - Mura
   - 5S
   - Kanban
   - VSM
   - Takt

3. **At some point in the risk management process you must attempt to estimate the frequency of occurrence your failure modes, which step in the process are you likely in:**
   - Risk Identification
   - Risk Analysis
   - Risk Detection
   - Risk Mitigation
   - Risk Evaluation

4. **The likelihood that the interval estimate contains the true population parameter is given by the _____.**
   A. Confidence Level
   B. Significance Level
   C. Alpha Risk
   D. Standard Error
   E. Point Estimate

5. **Fill in the blank: The concept of _____ is based on the assumption that any lot that gets rejected will be 100% sorted and any non-conformances will be replaced by a conforming unit.**
   - AOQ
   - LTPD
   - AQL
   - Acceptance Sampling
   - Switching Rules

6. **Fill in the blank: _____ is a workplace organization tool meant to organize, clean and standardize a workplace.**
   - Value Stream
   - Kanban
   - Muda
   - 5S
   - Gemba
   - Standard Work

7. **Risk is defined as the combination of the what two attributes:**
   - The likelihood of occurrence of a failure mode
   - The severity of that failure mode when it does occur
   - The detectability of a failure mode once it has occurred
   - The financial impact of a failure mode

8. **What is the critical z-value associated with a 2-sided confidence interval that's associated with a 1% alpha risk:**
   - z-score = 2.58
   - z-score = 2.33
   - z-score = 1.96
   - z-score = 3.09

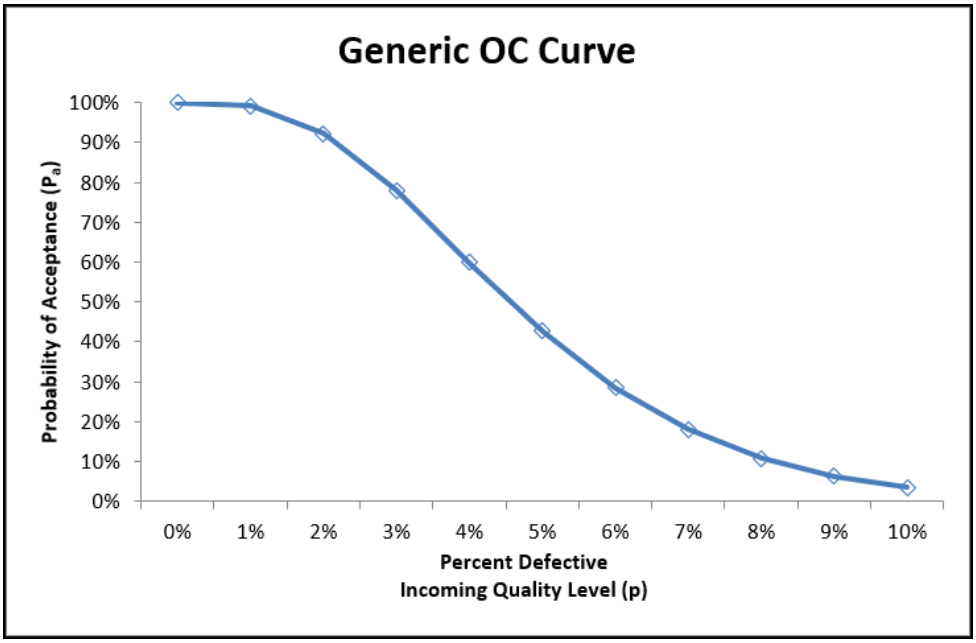
9. **A vendor has just shipped you 1000 units which you intend to inspect per ANSI/ASQ Z1.4 using a Single Sampling Plan at the normal, general level II inspection level at an AQL of 0.65. What is the sample size you must take:**
   - 50
   - 80
   - 125
   - 200

10. **Which form of waste is defined as the production of material before it is needed:**
   - Over-production
   - Motion
   - Inventory
   - Extra-processing
   - Defects
   - Non-Utilized Talent

11. **Identify the processes below that are included within Risk Control:**
   - Risk Acceptance
   - Risk Review
   - Risk Mitigation
   - Risk Reduction
   - Risk Management

12. **You're performing a hypothesis test for the population mean and your critical z-score is 1.65, and you've got a 2-sided test. If your z-statistic is -1.71, what would your conclusion be?**
   - Accept the null hypothesis and thus reject the alternative hypothesis
   - Fail to reject the null hypothesis
   - Fail to reject the alternative hypothesis
   - Reject the null hypothesis in favor of the alternative hypothesis

13. Below is the OC Curve for your newest sampling plan. What is the AQL associated with this plan:



- 1.5%
- 4.5%
- 5%
- 5.5%
- 8%

14. Match the following terms with their appropriate location on this table of Null & Alternative Hypothesis:

- Correct Decision to Fail to Reject the Null Hypothesis
- Type II Error
- Type I Error
- Correct Decision to Reject the Null Hypothesis

		The Truth	
		H_0 is True	H_0 is False
The Outcome of the Hypothesis Test	Fail to Reject H_0	A	B
	Reject H_0	C	*D*

15. **What is the primary purpose of a kanban system:**
    - To define the end-to-end activities within a value stream
    - To ensure that the flow of material only occurs at the pull of the customer
    - To study and reduce the time required to change-over equipment
    - To organize the workplace environment
    - To eliminate defects and rework
    - To capture the best, safety, most efficient method for conducting an activity

16. **Fill in the Blank: _____ is the risk that remains after all risk control & risk reductions measures have been taken to reduce risk.**
    - Remaining Risk
    - Reviewed Risk
    - Unacceptable Risk
    - Acceptable Risk
    - Residual Risk
    - Assessed Risk
    - Controlled Risk

17. **Fill in the blank: A _____ is defined as a collection of units that are all produced under the same conditions.**
    - Rational Subgroup
    - Proper Sample Size
    - Heterogenous Sample
    - Acceptance Sample
    - Discrete Control Chart
    - X-bar Chart

18. **What type of control chart would be used to monitor the number of defects for a process with a variable sample size:**
    - P Chart
    - NP Chart
    - C Chart
    - U Chart

19. **At the Fancy Pants corporation, an X-bar and R chart is used to monitor the length of pants during a production run where n=4 units are measured in each sample.**

    X-double bar is 24, R-bar is 3, n = 4.

    During the latest sample of 4 units the following values were measured (25, 28, 26, 27), what is the conclusion from this sample:

    - Both the average and range charts are within the statistical control limits
    - Both the average and range charts are out of the statistical control limits
    - The range is within control, however the average is out of statistical control
    - The average value is within control, however the range is out of statistical control

20. **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 and lower control limits for the range chart:

    - 0
    - 220.52
    - 229.48
    - 1.63
    - 5.73
    - 18.23
    - 22.37

21. **A team of engineers is working to qualify a new supplier for a critical component. You've asked the vendor to describe their manufacturing process in detail. Which Tool would be most effective in communicating the vendors manufacturing process:**
    - Flow Chart
    - Pareto Chart
    - FMEA Analysis
    - Tree Diagram

22. **A Light Bulb Manufacturer has just launched a brand-new bulb and complaints have been received for a short lifespan of the new bulb. A team of engineers have been assembled for root cause analysis. Which tool could be used to identify potential root causes that might be contributing to this event:**
    - Cause & Effect Diagram
    - Check Sheet
    - Flow Chart
    - Scatter Plot

23. **A burger joint wants to monitor the number of defective burgers cooked over time to identify if any changes have occurred within the process. Which tool can be used to assess performance of the cooking process over time:**
    - Control Chart
    - Flow Chart
    - Histogram
    - Pareto Chart

24. **A team of engineers is working to qualify a new supplier for a critical component. The supplier has informed the team that the critical dimension on their component is normally distributed. Which tool can be used to confirm the vendors assertion?**
    - Histogram
    - Control Chart
    - Check Sheet
    - Scatter Plot

25. **You're analyzing a complex process and want to communicate the relationship between the various factors associated with your process and the functional requirements associated with your product.**

    You've completed the testing and analysis and wish to visually display this relationship. Which tool is most appropriate to communicate this relationship:
    - Matrix Diagram
    - Flow Chart
    - Fishbone diagram
    - Process Decision Program Chart
    - Prioritization Matrix

26. **A team of various departments have been given the task of accomplishing a complex goal. They're holding a kick off meeting and wish to break the goal down into individual tasks, which tool would be best suited to accomplish this:**

- Tree Diagram
- Matrix Diagram
- Pareto Chart
- Histogram
- Prioritization Matrix

27. **A group of engineers have conducted a survey of customers and received a large quantity of feedback regarding their product. What quality tool will best help them organize and analyze this feedback?**

- Affinity Diagram
- Matrix Diagram
- Tree Diagram
- Interrelationship Digraph
- Check Sheet

28. **A team of subject matter experts have been assembled and brainstormed a large number of facts, data and ideas to determine the cause and effect relationships associated with a recent safety incident. What tool could be used to visualize and identify the primary causes of the safety incident:**

- Interrelationship Digraph
- Pareto Chart
- Control Chart
- Check Sheet
- Affinity Diagram
- Matrix Diagram

29. **Which of the following statements regarding Auditing is false:**
    - A QMS Audit is considered one of the most extensive audits
    - Auditors are required to keep all audit information & findings confidential
    - Auditors should wait until after the closing meetings to discuss any audit findings with the auditee
    - If requested, the auditor can make recommendations for corrective actions

30. **Which Role in an Audit is responsible for determining the need, objective & scope of the audit:**
    - The Auditee
    - The Lead Auditor
    - The Client
    - The Manager of the Audited Area

31. **Which of the following Audits could be described as Us Auditing Them:**
    - 1st Party Audit
    - 2nd Party Audit
    - 3rd Party Audit
    - Supplier Audit
    - Registration Audit

32. **Which of the following Audits can be described as a "Customer Focused" Audit:**
    - 3rd Party Audits
    - Compliance Audits
    - 1st Party Audits
    - Product Audits
    - Registration Audit

33. **A system is in its useful life period & has been shown to have a MTBF of 1,000 Hours. What is the Reliability of the system at 250 Hours?**
    - 77.8%
    - 75.6%
    - 71.0%
    - 73.2%

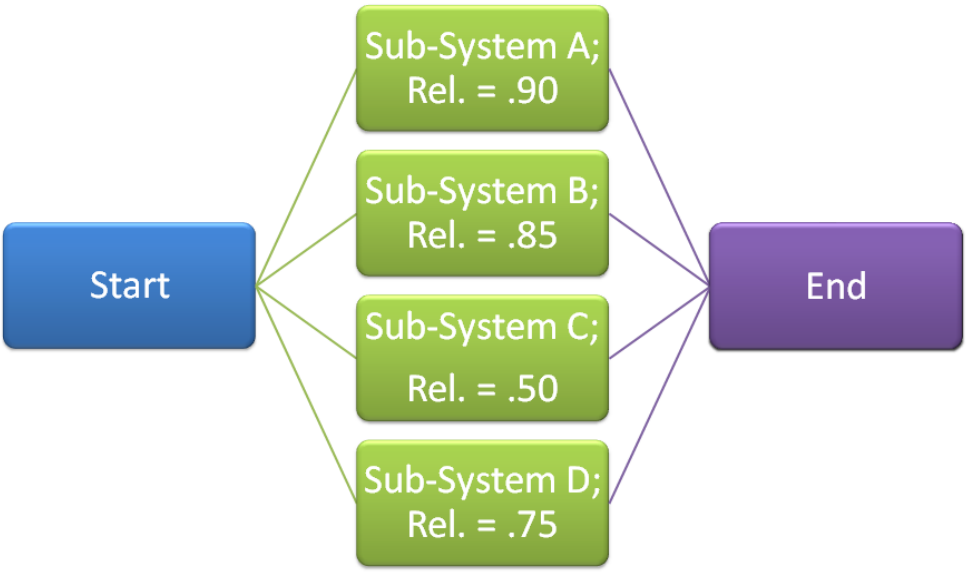
34. **What is the Y-Axis of the bathtub curve:**
    - MTTR
    - Time
    - Cumulative Failures
    - Reliability
    - Failure Rate
    - MTBF

35. **You've got a system that is comprised of 4 sub-systems, where the individual reliabilities of the sub-systems are known (see below):**

    Calculate the overall reliability of the entire system:

    - 28.7%
    - 22.1%
    - 99.8%
    - 34.4%

36. You've got a system that is comprised of 4 parallel sub-systems which operate in parallel to each other, where the individual reliabilities of the sub-systems are known (see below).



Calculate the overall reliability of the entire system:

- 96.4%
- 59.7%
- 99.8%
- 34.4%

37. Identify the elements below that can impact the precision of the measurement system:

- Linearity
- Stability
- Repeatability
- Reproducibility

38. **Repeatability in a Gauge R&R study is considered the variation introduced by what source or element of the measurement system:**
    - The Equipment
    - The Operator
    - The Process
    - The Tooling

39. **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:**
    - 0.821
    - 0.906
    - 0.728
    - 0.485

40. **You've executed a gauge R&R using the Average and Range method where the GR&R value is 0.1426 standard deviations. The feature being measured has an upper specification of 4.50" and a lower specification of 2.50". Is the measurement system capable?**
    - Yes, because the P/T ratio is less than 30%
    - No, because the P/T ratio is less than 30%
    - Yes, because the P/T ratio is greater than 30%
    - No, because the P/T ratio is greater than 30%

Solutions for Practice Exam

1. **Fill in the blank: _____ is commonly defined as the worst tolerable process average that is still considered acceptable.**
   - **AQL**
   - LTPD
   - AOQ
   - AOQL

2. **Fill in the blank: _____is defined as any activity that consumes resources but creates no value for the customer.**
   - **Muda**
   - Muri
   - Mura
   - 5S
   - Kanban
   - VSM
   - Takt

3. **At some point in the risk management process you must attempt to estimate the frequency of occurrence your failure modes, which step in the process are you likely in:**
   - Risk Identification
   - **Risk Analysis**
   - Risk Detection
   - Risk Mitigation
   - Risk Evaluation

4. **The likelihood that the interval estimate contains the true population parameter is given by the _____**
   - **F. Confidence Level**
   - G. Significance Level
   - H. Alpha Risk
   - I. Standard Error
   - J. Point Estimate

5. **Fill in the blank: The concept of _____ is based on the assumption that any lot that gets rejected will be 100% sorted and any non-conformances will be replaced by a conforming unit.**
   - **AOQ**
   - LTPD
   - AQL
   - Acceptance Sampling
   - Switching Rules

6. **Fill in the blank: _____ is a workplace organization tool meant to organize, clean and standardize a workplace.**
   - Value Stream
   - Kanban
   - Muda
   - **5S**
   - Gemba
   - Standard Work

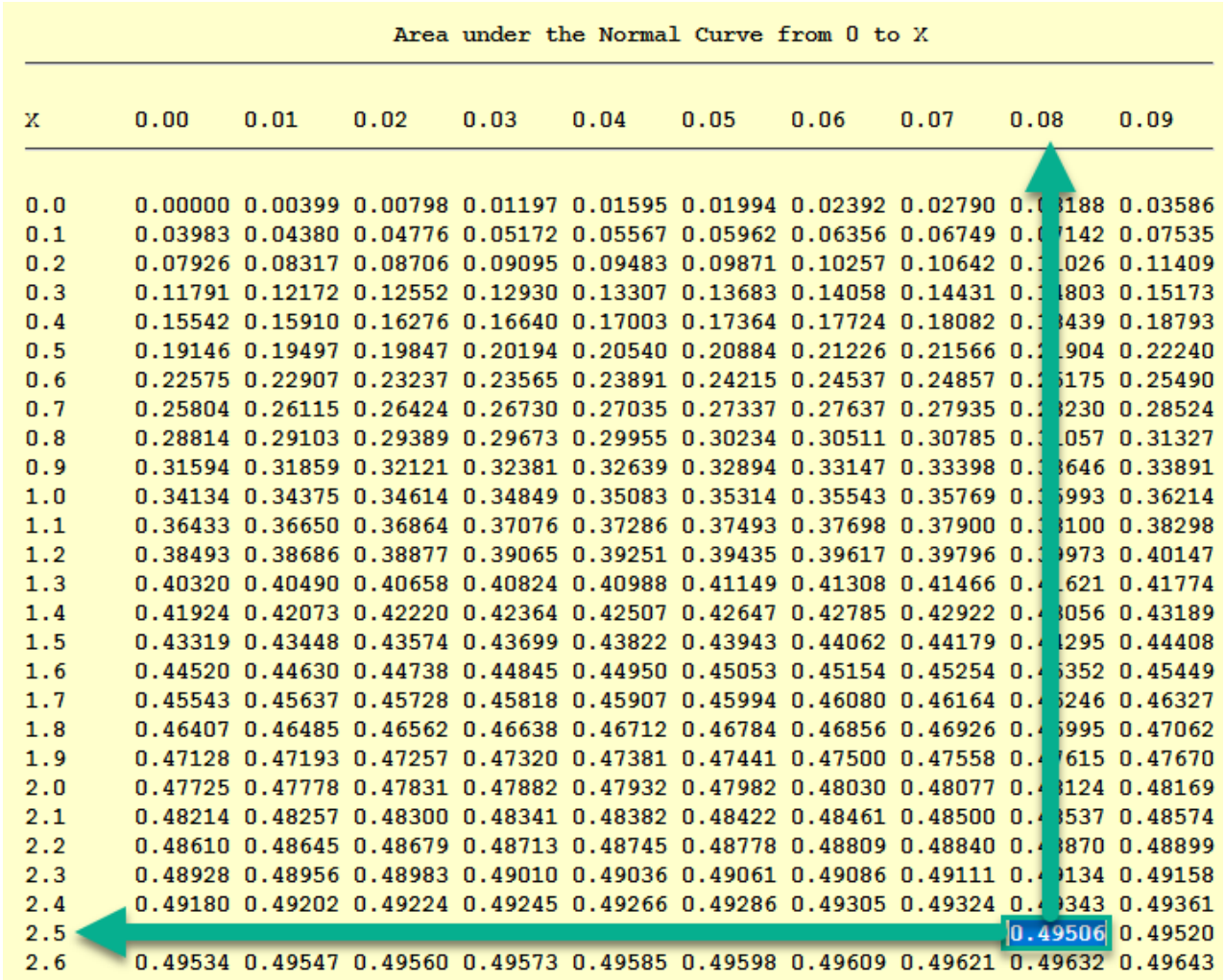
7. **Risk is defined as the combination of the what two attributes:**
   - **The likelihood of occurrence of a failure mode**
   - **The severity of that failure mode when it does occur**
   - The detectability of a failure mode once it has occurred
   - The financial impact of a failure mode

8. **What is the critical z-value associated with a 2-sided confidence interval that's associated with a 1% alpha risk.** [NIST Z-Table for Normal Distribution]

- z-score = 2.33
- **z-score = 2.58**
- z-score = 1.96
- z-score = 3.09

When you've got a 1% alpha risk, your Z-score must capture 99% of the distribution, which translates to 49.5% on each half of the distribution since we're creating a 2-sided confidence interval.

Thus we're looking for a z-score that's associated with the area under the curve of 0.495, which is equal to **Z = 2.58.**



Area under the Normal Curve from 0 to X

X	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.00000	0.00399	0.00798	0.01197	0.01595	0.01994	0.02392	0.02790	0.03188	0.03586
0.1	0.03983	0.04380	0.04776	0.05172	0.05567	0.05962	0.06356	0.06749	0.07142	0.07535
0.2	0.07926	0.08317	0.08706	0.09095	0.09483	0.09871	0.10257	0.10642	0.11026	0.11409
0.3	0.11791	0.12172	0.12552	0.12930	0.13307	0.13683	0.14058	0.14431	0.14803	0.15173
0.4	0.15542	0.15910	0.16276	0.16640	0.17003	0.17364	0.17724	0.18082	0.18439	0.18793
0.5	0.19146	0.19497	0.19847	0.20194	0.20540	0.20884	0.21226	0.21566	0.21904	0.22240
0.6	0.22575	0.22907	0.23237	0.23565	0.23891	0.24215	0.24537	0.24857	0.25175	0.25490
0.7	0.25804	0.26115	0.26424	0.26730	0.27035	0.27337	0.27637	0.27935	0.28230	0.28524
0.8	0.28814	0.29103	0.29389	0.29673	0.29955	0.30234	0.30511	0.30785	0.31057	0.31327
0.9	0.31594	0.31859	0.32121	0.32381	0.32639	0.32894	0.33147	0.33398	0.33646	0.33891
1.0	0.34134	0.34375	0.34614	0.34849	0.35083	0.35314	0.35543	0.35769	0.35993	0.36214
1.1	0.36433	0.36650	0.36864	0.37076	0.37286	0.37493	0.37698	0.37900	0.38100	0.38298
1.2	0.38493	0.38686	0.38877	0.39065	0.39251	0.39435	0.39617	0.39796	0.39973	0.40147
1.3	0.40320	0.40490	0.40658	0.40824	0.40988	0.41149	0.41308	0.41466	0.41621	0.41774
1.4	0.41924	0.42073	0.42220	0.42364	0.42507	0.42647	0.42785	0.42922	0.43056	0.43189
1.5	0.43319	0.43448	0.43574	0.43699	0.43822	0.43943	0.44062	0.44179	0.44295	0.44408
1.6	0.44520	0.44630	0.44738	0.44845	0.44950	0.45053	0.45154	0.45254	0.45352	0.45449
1.7	0.45543	0.45637	0.45728	0.45818	0.45907	0.45994	0.46080	0.46164	0.46246	0.46327
1.8	0.46407	0.46485	0.46562	0.46638	0.46712	0.46784	0.46856	0.46926	0.46995	0.47062
1.9	0.47128	0.47193	0.47257	0.47320	0.47381	0.47441	0.47500	0.47558	0.47615	0.47670
2.0	0.47725	0.47778	0.47831	0.47882	0.47932	0.47982	0.48030	0.48077	0.48124	0.48169
2.1	0.48214	0.48257	0.48300	0.48341	0.48382	0.48422	0.48461	0.48500	0.48537	0.48574
2.2	0.48610	0.48645	0.48679	0.48713	0.48745	0.48778	0.48809	0.48840	0.48870	0.48899
2.3	0.48928	0.48956	0.48983	0.49010	0.49036	0.49061	0.49086	0.49111	0.49134	0.49158
2.4	0.49180	0.49202	0.49224	0.49245	0.49266	0.49286	0.49305	0.49324	0.49343	0.49361
2.5									0.49506	0.49520
2.6	0.49534	0.49547	0.49560	0.49573	0.49585	0.49598	0.49609	0.49621	0.49632	0.49643

9. **A vendor has just shipped you 1000 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 0.65. What is the sample size you must take:**
   - 50
   - **80**
   - 125
   - 200

Using the attribute sampling size code letters that correspond to ANSI/ASQ Z1.4 sampling, you'll see that a lot size of 1000 units, at the general inspection level II corresponds to a sample size code letter of J.

Lot or Batch Size	Special Inspection Levels				General Inspection Levels		
	S-1	S-2	S-3	S-4	I	II	III
2 to 8	A	A	A	A	A	A	B
9 to 15	A	A	A	A	A	B	C
16 to 25	A	A	B	B	B	C	D
26 to 50	A	B	B	C	C	D	E
51 to 90	B	B	C	C	C	E	F
91 to 150	B	B	C	D	D	F	G
151 to 280	B	C	D	E	E	G	H
281 to 500	B	C	D	E	F	H	J
501 to 1200	C	C	E	F	G	J	K
1201 to 3200	C	D	E	G	H	K	L
3201 to 10000	C	D	F	G	J	L	M
10001 to 35000	C	D	F	H	K	M	N
35001 to 150000	D	E	G	J	L	N	P
150001 to 500000	D	E	G	J	M	P	Q
> 500001	D	E	H	K	N	Q	R

Using the single normal inspection table associated with ANSI Z1.4 you'll find that the sample size for code letter J is 80 samples at the AQL of 0.65.

Sample Size Code Letter	Sample Size	AQL (Acceptance Quality Limit) for Normal Inspection												
		0.25	0.4	0.65	1	1.5	2.5	4	6.5	10	15	25	40	65
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A	2	↓	↓	↓	↓	↓	↓	↓	0 1	↓	↓	1 2	2 3	3 4
B	3	↓	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6
C	5	↓	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8
D	8	↓	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11
E	13	↓	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15
F	20	↓	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22
G	32	↓	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑
H	50	0 1	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑
J	80	↑	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑
K	125	↓	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑
L	200	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑
M	315	2 3	3 4	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑
N	500	3 4	5 6	7 8	10 11	**14 15**	21 22	↑	↑	↑	↑	↑	↑	↑
P	800	5 6	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑
Q	1250	7 8	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑
R	2000	10 11	14 15	21 22	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑

10. **Which form of waste is defined as the production of material before it is needed:**
    - **Over-production**
    - Motion
    - Inventory
    - Extra-processing
    - Defects
    - Non-Utilized Talent

11. **Identify the processes below that are included within Risk Control:**
    - **Risk Acceptance**
    - Risk Review
    - Risk Mitigation
    - **Risk Reduction**
    - Risk Management

12. **You're performing a hypothesis test for the population mean and your critical z-score is 1.65, and you've got a 2-sided test. If your z-statistic is -1.71, what would your conclusion be?**

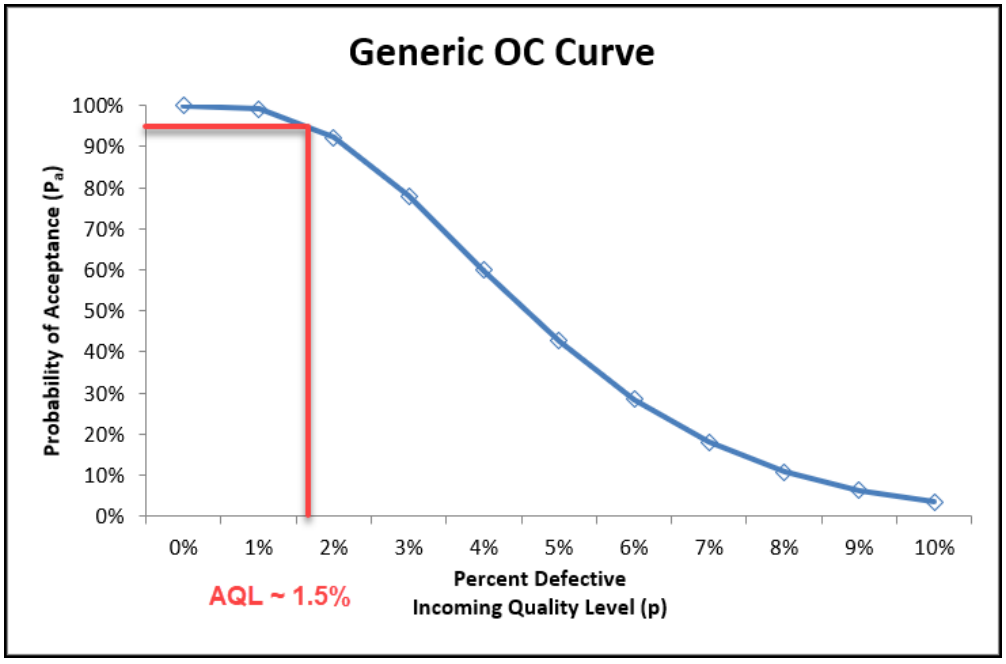
    - Accept the null hypothesis and thus reject the alternative hypothesis
    - Fail to reject the null hypothesis
    - Fail to reject the alternative hypothesis
    - **Reject the null hypothesis in favor of the alternative hypothesis**

Because it is a 2-sided hypothesis test, you'll be looking for a value greater than 1.65, or less than -1.65. Because our value is less than -1.65, we can **reject the null hypothesis in favor of the alternative hypothesis.**

13. Below is the OC Curve for your newest sampling plan. What is the AQL associated with this plan:

- **1.5%**
- 4.5%
- 5%
- 5.5%
- 8%

The AQL for your sampling plan corresponds with the 95% probability of acceptance, which I've drawn on the graph below.



This 95% probability of acceptance corresponds with an **AQL of ~1.5.**

14. **Match the following terms with their appropriate location on this table of Null & Alternative Hypothesis:**
    - A - Correct Decision to Fail to Reject the Null Hypothesis
    - B - Type II Error
    - C - Type I Error
    - D - Correct Decision to Reject the Null Hypothesis

		The Truth	
		H_0 is True	H_0 is False
The Outcome of the Hypothesis Test	Fail to Reject H_0	Correct Decision	INCORRECT DECISION (Type II Error) Beta (β) Risk
	Reject H_0	INCORRECT DECISION (Type I Error) Alpha (α) risk	Correct Decision *Power (1 - β)*

15. **What is the primary purpose of a kanban system:**
    - To define the end-to-end activities within a value stream
    - **To ensure that the flow of material only occurs at the pull of the customer**
    - To study and reduce the time required to change-over equipment
    - To organize the workplace environment
    - To eliminate defects and rework
    - To capture the best, safety, most efficient method for conducting an activity

16. **Fill in the Blank: _____ is the risk that remains after all risk control & risk reductions measures have been taken to reduce risk.**
    - Remaining Risk
    - Reviewed Risk
    - Unacceptable Risk
    - Acceptable Risk
    - **Residual Risk**
    - Assessed Risk
    - Controlled Risk

17. **Fill in the blank: A _____ is defined as a collection of units that are all produced under the same conditions.**
    - **Rational Subgroup**
    - Proper Sample Size
    - Heterogenous Sample
    - Acceptance Sample
    - Discrete Control Chart
    - X-bar Chart

18. **What type of control chart would be used to monitor the number of defects for a process with a variable sample size:**
    - P Chart
    - NP Chart
    - C Chart
    - **U Chart**

You can see in the matrix below that if you're monitoring **defects** with a **variable sample size**, the **U Chart** is the appropriate control chart.

		Sample Size	
		Constant	**Variable**
Type	**Defect**	c Chart	u Chart
	Defectives	np Chart	p Chart

19. At the Fancy Pants corporation, an X-bar and R chart is used to monitor the length of pants during a production run where n=4 units are measured in each sample.

X-double bar is 24, R-bar is 3, n = 4.

During the latest sample of 4 units the following values were measured (25, 28, 26, 27), what is the conclusion from this sample:

- Both the average and range charts are within the statistical control limits
- Both the average and range charts are out of the statistical control limits
- **The range is within control, however the average is out of statistical control**
- The average value is within control, however the range is out of statistical control

First, **we must calculate the average and rang**e associated with this latest sample of 4 units (25, 28, 26, 27).

- The range is 3,
- The average is 26.5.

Now we must calculate our control limits for our process.

$$\boldsymbol{UCL_{\bar{X}}} = \bar{\bar{X}} + A_2\bar{R} = 24 + 0.729 * 3 = 26.19$$

$$\boldsymbol{LCL_{\bar{X}}} = \bar{\bar{X}} - A_2\bar{R} = 24 - 0.729 * 3 = 21.81$$

$$\boldsymbol{UCL_R} = D_4\bar{R} = 2.282 * 3 = 6.846$$

$$\boldsymbol{LCL_R} = D_3\bar{R} = 0 * 3 = 0$$

Now we can compare our values (Range = 3, Average = 26.5) against the control limits.

The measured range of 3 is within the control limits, however the average value (26.5) is greater than the upper control limit (26.19).

20. 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 and lower control limits for the range chart:

- 0
- 220.52
- 229.48
- **1.63**
- 5.73
- 18.23
- **22.37**

First, we must look up the constants required to calculate the control limits for the range chart using the sample size (n=8), and we find $D_3 = 0.136$ and $D_4 = 1.864$.

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

Now we can calculate the control limits for the Range control chart:

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

$$\boldsymbol{LCL_R} = D_3 * \bar{R} = 0.136 * 12 = 1.63$$

21. **A team of engineers is working to qualify a new supplier for a critical component. You've asked the vendor to describe their manufacturing process in detail. Which Tool would be most effective in communicating the vendors manufacturing process:**

- **Flow Chart**
- Pareto Chart
- FMEA Analysis
- Tree Diagram

22. **A Light Bulb Manufacturer has just launched a brand-new bulb and complaints have been received for a short lifespan of the new bulb. A team of engineers have been assembled for root cause analysis. Which tool could be used to identify potential root causes that might be contributing to this event:**

- **Cause & Effect Diagram**
- Check Sheet
- Flow Chart
- Scatter Plot

23. **A burger joint wants to monitor the number of defective burgers cooked over time to identify if any changes have occurred within the process. Which tool can be used to assess performance of the cooking process over time:**
- **Control Chart**
- Flow Chart
- Histogram
- Pareto Chart

24. **A team of engineers is working to qualify a new supplier for a critical component. The supplier has informed the team that the critical dimension on their component is normally distributed. Which tool can be used to confirm the vendors assertion?**
- **Histogram**
- Control Chart
- Check Sheet
- Scatter Plot

25. **You're analyzing a complex process and want to communicate the relationship between the various factors associated with your process and the functional requirements associated with your product.**

    You've completed the testing and analysis and wish to visually display this relationship. Which tool is most appropriate to communicate this relationship:

    - **Matrix Diagram**
    - Flow Chart
    - Fishbone diagram
    - Process Decision Program Chart
    - Prioritization Matrix

    The **Matrix Diagram** is a tool that is meant to explore, visualize and communicate the strength of relationships between different factors associated with a complex process, project or product.

26. **A team of various departments have been given the task of accomplishing a complex goal. They're holding a kick off meeting and wish to break the goal down into individual tasks, which tool would be best suited to accomplish this:**

    - **Tree Diagram**
    - Matrix Diagram
    - Pareto Chart
    - Histogram
    - Prioritization Matrix

    The **Tree Diagram** is a visual tool to identify (via brainstorming) & outline all the necessary steps to complete a complex project. This tool breaks down a broad goal into specific tasks.

27. **A group of engineers have conducted a survey of customers and received a large quantity of feedback regarding their product. What quality tool will best help them organize and analyze this feedback?**

    - **Affinity Diagram**
    - Matrix Diagram
    - Tree Diagram
    - Interrelationship Digraph
    - Check Sheet

    The **Affinity Diagram** is a tool that facilitates brainstorming and organizes facts and data into themes or groups of common characteristics.

28. **A team of subject matter experts have been assembled and brainstormed a large number of facts, data and ideas to determine the cause and effect relationships associated with a recent safety incident. What tool could be used to visualize and identify the primary causes of the safety incident:**

- **Interrelationship Digraph**
- Pareto Chart
- Control Chart
- Check Sheet
- Affinity Diagram
- Matrix Diagram

The **interrelationship digraph** is a tool you can use to analyze a complex problem to identify the cause and effect relationships that exist between disparate facts.

29. **Which of the following statements regarding Auditing is false:**

- A QMS Audit is considered one of the most extensive audits
- Auditors are required to keep all audit information & findings confidential
- **Auditors should wait until after the closing meetings to discuss any audit findings with the auditee**
- If requested, the auditor can make recommendations for corrective actions

All audit findings should be discussed with the auditee in the closing meeting.

30. **Which Role in an Audit is responsible for determining the need, objective & scope of the audit:**

- The Auditee
- The Lead Auditor
- **The Client**
- The Manager of the Audited Area

31. Which of the following Audits could be described as Us Auditing Them:

- 1st Party Audit
- **2nd Party Audit**
- 3rd Party Audit
- **Supplier Audit**
- Registration Audit

2nd Party Audits and Supplier Audits can be described as Us Auditing Them.

1st Party Audits are Us Auditing Us, 3rd Party Audits are Them Auditing Them or Us, and Registration Audits are Them Auditing Us

32. Which of the following Audits can be described as a "Customer Focused" Audit:

- 3rd Party Audits
- Compliance Audits
- 1st Party Audits
- **Product Audits**
- Registration Audit

The **Product Audit** is meant to verify **Form/Fit & Function** from the customers perspective. They are also meant to verify **Fitness For Use** by the customer.

33. A system is in its useful life period & has been shown to have a MTBF of 1,000 Hours. What is the Reliability of the system at 250 Hours?

- **77.8%**
- 75.6%
- 71.0%
- 73.2%

The first step in solving this problem is understanding that because the system is in its **useful life period**, you should use the **Exponential Distribution** to calculate **reliability**, see below:

$$R(t) = e^{-\lambda t} \; Where \; MTBF = \theta = \frac{1}{\lambda}$$

$$R(250) = e^{\frac{-t}{\theta}} = e^{\frac{-250}{1{,}000}} = e^{\frac{-1}{4}}$$

$$R(250) = .7788 \; or \; 77.88\% \; Reliability$$

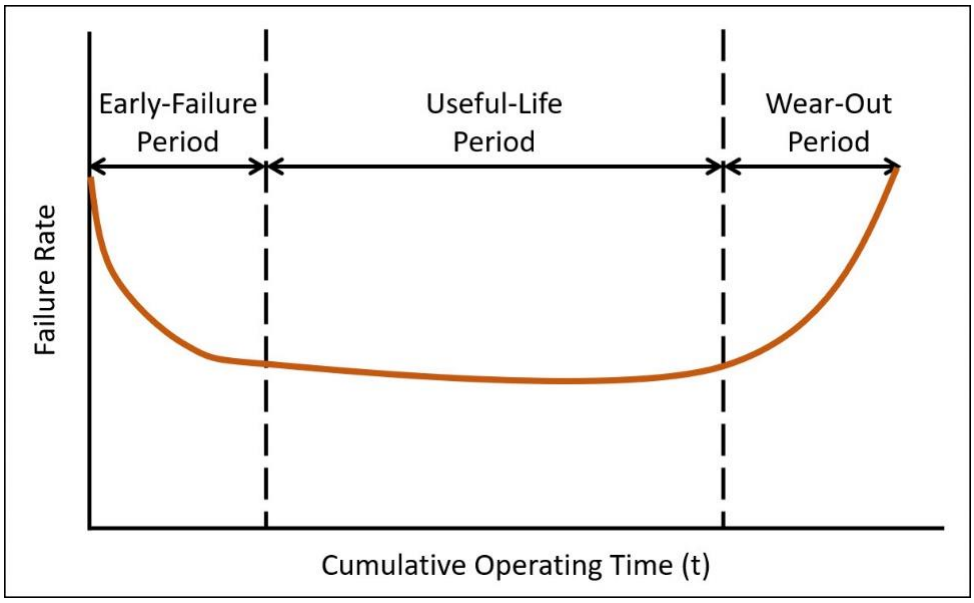
Using this equation, we can estimate the **Reliability at 250 Hours to be 77.88%**. This means that there is a 77.8% likelihood that a unit will survive past the 250-hour mark.

This reliability number (77.8%) can also be interpreted to mean that 77.8% of similar units are still functioning properly.

34. What is the Y-Axis of the bathtub curve:

- MTTR
- Time
- Cumulative Failures
- Reliability
- **Failure Rate**
- MTBF

The Y-Axis of the bathtub curve is – **Failure Rate**, which you can see below. This bathtub curve models the reliability of a system over time.



35. **You've got a system that is comprised of 4 sub-systems, where the individual reliabilities of the sub-systems are known (see below):**

    Calculate the overall reliability of the entire system:

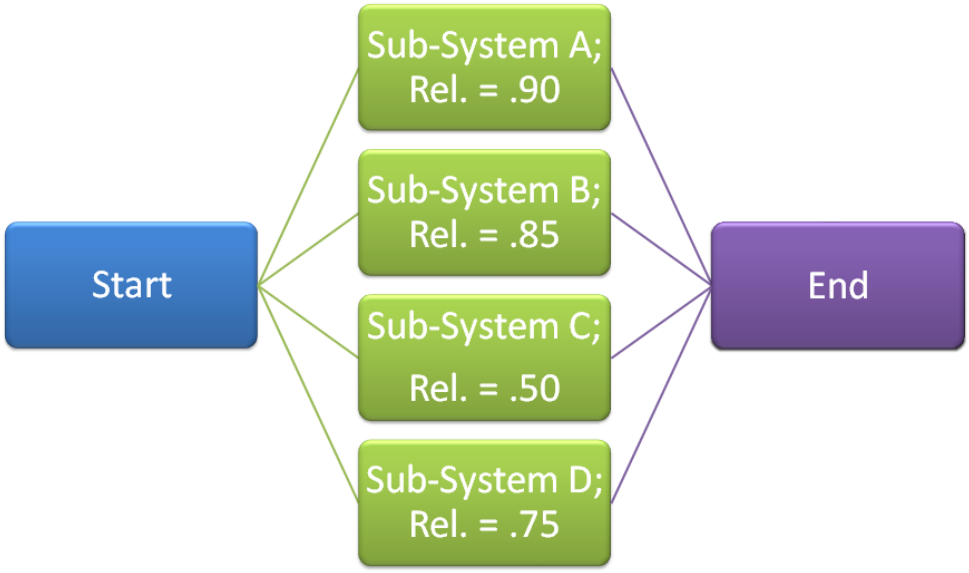
- **28.7%**
- 22.1%
- 99.8%
- 34.4%

Below is the equation to calculate the overall system reliability for a series system.

$$Series\ System\ Reliability = R_{system} = R_1 \times R_2 \times R_3 \times R_4$$

$$Series\ System\ Reliability = R_{system} = .90 \times .85 \times .50 \times .75 = 28.7\%$$

36. You've got a system that is comprised of 4 parallel sub-systems which operate in parallel to each other, where the individual reliabilities of the sub-systems are known (see below).



Calculate the overall reliability of the entire system:

- 96.4%
- 59.7%
- **99.8%**
- 34.4%

Below is the equation to calculate the overall system reliability for a parallel system.

$$Parallel\ System\ Reliability = R_{system} = 1 - (U_1 \times U_2 \times U_3 \times U_4)$$

$$Where\ U_1 = 1 - R_1 = 1 - 0.90 = 0.10$$

$$Where\ U_2 = 1 - R_2 = 1 - 0.85 = 0.15$$

$$Where\ U_3 = 1 - R_3 = 1 - 0.50 = 0.50$$

$$Where\ U_4 = 1 - R_4 = 1 - 0.75 = 0.25$$

$$Parallel\ System\ Reliability = R_{system} = 1 - (0.10 \times 0.15 \times 0.50 \times 0.25) = 99.8\%\ Reliability$$

37. Identify the elements below that can impact the precision of the measurement system:

- Linearity
- Stability
- **Repeatability**
- **Reproducibility**

Repeatability and Reproducibility are the elements of precision for a measurement system.

Linearity and Stability can only impact the accuracy of a measurement system, not the precision.

38. Repeatability in a Gauge R&R study is considered the variation introduced by what source or element of the measurement system:

- **The Equipment**
- The Operator
- The Process
- The Tooling

Repeatability within measurement system analysis is meant to only capture the variation of the measurement equipment itself.

Other sources of variation like the operator, the process and the tooling impact the other element of measurement precision: **reproducibility**.

39. 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:

- 0.821
- 0.906
- 0.728
- **0.485**

The following equation can be used to calculate the repeatability when using the Average and Range Method for gauge R&R.

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

We already know the **average range (R-double bar = 0.821)**, and then we can look up the d_2 coefficient from the following table.

First, we must determine the **number of samples (n)** involved in this calculation, which can be calculated as the number of parts multiplied by the number of operators involved in the experiment.

n = (# of parts) * (# of operators) = 10 * 3 = 30

With **n** being greater than 30, we can simply use $d^*_2 = 1.693$.

Let's go back to original equation and calculate repeatability.

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

# Samples	Sub-group size (m)		
(n)	2	3	4
1	1.414	1.912	2.239
2	1.279	1.805	2.151
3	1.231	1.769	2.120
4	1.206	1.750	2.105
5	1.191	1.739	2.096
6	1.181	1.731	2.090
7	1.173	1.726	2.085
8	1.168	1.721	2.082
9	1.164	1.718	2.080
10	1.160	1.716	2.077
11	1.157	1.714	2.076
12	1.155	1.712	2.074
13	1.153	1.710	2.073
14	1.151	1.709	2.072
15	1.150	1.708	2.071
d^*_2	1.128	1.693	2.059

40. You've executed a gauge R&R using the Average and Range method where the GR&R value is 0.1426 standard deviations. The feature being measured has an upper specification of 4.50" and a lower specification of 2.50". Is the measurement system capable?

- Yes, because the P/T ratio is less than 30%
- No, because the P/T ratio is less than 30%
- Yes, because the P/T ratio is greater than 30%
- **No, because the P/T ratio is greater than 30%**

First, let's start by reviewing the calculation for **the precision / tolerance ratio:**

$$Precision\ Tolerance\ Ratio = \frac{Total\ Measurement\ System\ Variation}{Tolerance} = \frac{6 * \sigma_{GRR}}{Upper\ Spec. - Lower\ Spec.}$$

Let's plug in our numbers for **GR&G (0.1426)** and the specification limits **(4.50 and 2.50)** and complete the calculation.

$$\frac{P}{T}\ Ratio = \frac{6 * \sigma_{GRR}}{Upper\ Spec. - Lower\ Spec.} = \frac{6 * 0.1426}{4.50 - 2.50} = \frac{0.8556}{2} = 0.4278 = \mathbf{42.78\%}$$

Now we must interpret this P/T value of 42.78%.

In general, if the total measurement error is **greater than 30%**, then the measurement system is usually not considered acceptable. This indicates that there are sources of variation within the measurement system that must be eliminated prior to use.

In this case we can answer the original question about **measurement system capability**:

No, the measurement system is not considered to be capable because the P/T ratio is greater than 30%.

Note, I chose to multiple the GR&R (0.1426) by 6.

Other texts recommend a factor of 5.15.

In either case, the system is considered incapable.