QUESTIONS:

1. **Fill in the Blank: ______________________ means confirmation by examination & evaluation of objective evidence to confirm that your final product meets the customer's needs & intended use.**
   - Design Verification
   - Design Validation
   - Design Qualification
   - Design V&V Protocol

2. **6 units that are operating within their useful life period are put on test for a total of 10,000 hours. The following 3 units were found to fail at these times (5,500 hours, 4,400 hours, and 3,300 hours).**

   Calculate the systems failure rate based on this data:
   - 0.000455
   - 0.000069
   - 0.000139
   - 0.000227

3. **A probability model & mathematics equation that describe the failure frequency over time is commonly known as what:**
   - Reliability Function
   - Cumulative Density Function
   - Probability Density Function
   - The Bathtub Curve

4. **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?**
   - 75.6%
   - 77.8%
   - 73.2%
   - 71.0%

5. **A system is in its useful life period & has a MTBF of 1,000 hours. At what point in time is the likelihood for failure equal to the likelihood for success:**
   - 500
   - 307
   - 693
   - 721

6. **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

7. **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

8. **You're constructing an NP chart, where you've sampled from 25 subgroups, each with 100 samples, and found a total of 145 defective units. Calculate the UCL for this process.**

   - Not Enough Information Provided
   - 5.8
   - 0.058
   - 7.0
   - 12.8
   - 14.5

9. **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

10. **You're performing a hypothesis test for the population mean, and your sample mean is 2.53, your null hypothesis for the population mean is 2.50, your sample size is 50 and your population standard deviation is 0.10.**

    Calculate your z test statistic:
    - 0.300
    - 1.732
    - 2.121
    - 2.460

11. You're performing a hypothesis test for the population mean and you know the population standard deviation. You plan to sample 60 units from your population and you'd like to use a 1-sided test at a 1% significance level.

What is the rejection criteria for this hypothesis test?

See attachment with Z-Table & T-Tables for reference.

- 1.650
- 1.96
- 2.33
- 2.39
- 2.58

12. Which distribution is used to make the accept/reject decision for a hypothesis test for the slope coefficient (β_1) within linear regression:

- Chi-squared distribution
- T-distribution
- Binomial distribution
- Normal distribution
- None of the above

13. Fill in the Blanks: The linear regression method models the relationship between _______A_______ mathematically with _________B_________.

- A – Variables
- A –Coefficients
- A – Statistics
- A – Parameters
- B – Statistics
- B – Coefficients
- B – Equations
- B – Parameters

14. A manufacturing operation produces a part that follows the normal distribution with a mean weight of 45 ounces and a standard deviation of 2 ounces. Estimate the percentage of the overall population that would get manufactured less than 42 ounces.

- 57.3%
- 43.3%
- 93.2%
- 6.8%

15. Fill in the blank: _________________ is the concept that, between trials in an experiment, the results of the 1st experiment do not affect the results of the 2nd experiment.

- Constant probability of occurrence
- Independence
- Fixed Trials
- Identical Trials

SOLUTIONS:

1. **Fill in the Blank: _______________________ means confirmation by examination & evaluation of objective evidence to confirm that your final product meets the customer's needs & intended use.**
   - Design Verification
   - **Design Validation**
   - Design Qualification
   - Design V&V Protocol

2. **6 units that are operating within their useful life period are put on test for a total of 10,000 hours. The following 3 units were found to fail at these times (5,500 hours, 4,400 hours, and 3,300 hours).**

   Calculate the systems failure rate based on this data:

   - 0.000455
   - **0.000069**
   - 0.000139
   - 0.000227

   Let's calculate failure rate using the following equation. Remember, six (6) units were put on test. Only 3 units failed, while the other 3 did not fail throughout the entire 10,000-hour test.

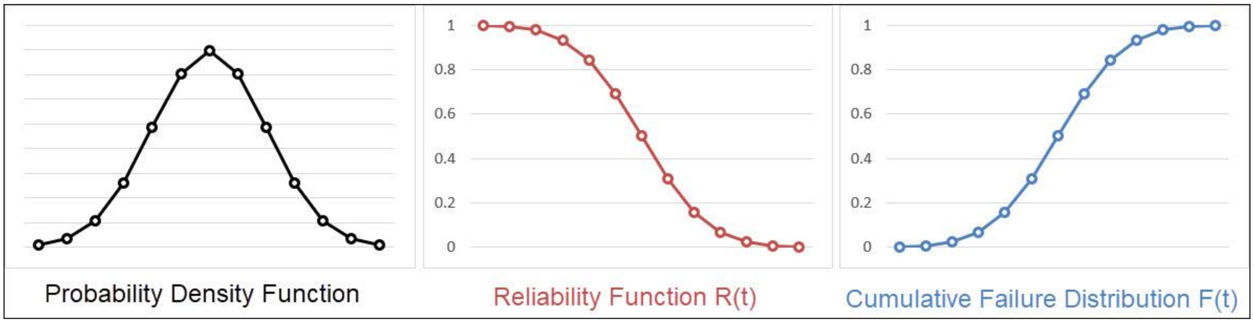
$$\boldsymbol{Failure\ Rate = \lambda = \frac{1}{MTBF}}$$

$$\boldsymbol{MTBF} = \frac{Operating\ Time}{Number\ of\ Failures} = \frac{5{,}500 + 4{,}400 + 3{,}300 + 10{,}000 + 10{,}000 + 10{,}000}{3} = \frac{43{,}200}{3} = 14{,}400$$

$$\boldsymbol{Failure\ Rate = \lambda = \frac{1}{14,000} = 0.000069}$$

3. **A probability model & mathematics equation that describe the failure frequency over time is commonly known as what:**
   - Reliability Function
   - Cumulative Density Function
   - **Probability Density Function**
   - The Bathtub Curve

A **Probability Density Function** is probability model & mathematics equation that describe the failure frequency over time.



The cumulative density function (CDF) which shows the cumulative area under the PDF curve modeled as its own mathematical function**.**

The **Reliability Function** is the inverse of the CDF & estimates the probability that a unit will be operational at any given time.

4. 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?

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

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

We can plug in the time value (250 hours), and the MTBF (1,000 hours) to calculate the reliability.

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

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

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

Using this equation, we can estimate the Reliability at 250 Hours to be 77.88%

5. **A system is in its useful life period & has a MTBF of 1,000 hours. At what point in time is the likelihood for failure equal to the likelihood for success:**
   - 500
   - 307
   - **693**
   - 721

   The first step in solving this problem is understanding that because the system is in its useful life period, we must use the Exponential Distribution to calculate reliability.

   The below equation can be used to calculate reliability for an exponential distribution:

$$\boldsymbol{Reliability}:\quad R(t) = e^{-\lambda t} = e^{\frac{-t}{\theta}}$$

   The point in time where the likelihood for failure being equal to the likelihood for success means that the reliability of the system is 50% or 0.50

$$R(t) = 0.50 = e^{-\lambda t} = e^{\frac{-t}{\theta}}$$

Where

$$\boldsymbol{\theta = MTBF = 1,000}$$

   Now we can solve for the time value (t) associated with a reliability of 50%.

$$R(t) = 0.50 = e^{\frac{-t}{1,000}}$$

   We can solve for t by taking the natural log (LN) of the exponential (e).

$$\boldsymbol{LN(.50) = \frac{-t}{1,000}}$$

$$\boldsymbol{t = -1,000 * LN(.50) = 693\ Hours}$$

6. **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 = 2.58**
   - ~~z-score = 2.33~~
   - ~~z-score = 1.96~~
   - ~~z-score = 3.09~~

   Because it's a 2-sided distribution, we're looking for the z-score that's associated with the area under the curve of 0.495.

   This would capture 49.5% on the left half & right half of the distribution, leaving the remaining 1% of the alpha risk in the rejection area of the tails of the distribution.

The z-score associated with 0.495 probability is 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

7. 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**

8. You're constructing an NP chart, where you've sampled from 25 subgroups, each with 100 samples, and found a total of 145 defective units. Calculate the UCL for this process.

- Not Enough Information Provided
- 5.8
- 0.058
- 7.0
- **12.8**
- 14.5

The upper control limit of an NP Chart is calculated using the following equation:

$$UCL_{np} = n\overline{p} + 3\sqrt{n\bar{p}(1-\bar{p})}$$

To execute this equation, we need to know the following variables:

$$\bar{p} = \%\, Defective$$

$$n\bar{p}\ Centerline = \frac{\sum np}{k}$$

Let's use our information from the problem statement to calculate these variables:

$$\bar{p} = \frac{\sum np}{\sum n} = \frac{Sum\ of\ All\ Defectives}{Sum\ of\ Subgroup\ Quantity} = \frac{145}{2500} = 0.058$$

$$n\bar{p}\ Centerline = \frac{\sum np}{k} = \frac{Sum\ of\ All\ Defectives}{\#\ of\ subgroups} = \frac{145}{25} = 5.8$$

Now we can plug these variables back into the equation for the upper control limit:

$$UCL_{np} = n\overline{p} + 3\sqrt{n\bar{p}(1-\bar{p})}$$

$$UCL_{np} = 5.8 + 3\sqrt{5.8(1-0.058)} = 5.8 + 7.0 = 12.8\text{jmn}$$

$$\boldsymbol{UCL_{np} = 5.8 + 7.0 = 12.8}$$

9. 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.

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

10. You're performing a hypothesis test for the population mean, and your sample mean is 2.53, your null hypothesis for the population mean is 2.50, your sample size is 50 and your population standard deviation is 0.10.

Calculate your z test statistic:

In this instance our hypothesis test sample size is greater than 30 and we know the population standard deviation; therefore we can use the normal distribution and z-score for our test statistic.

$$\boldsymbol{z = \frac{\bar{x} - \mu}{\frac{\sigma}{\sqrt{n}}} = \frac{2.53 - 2.50}{\frac{0.10}{\sqrt{50}}} = 2.121}$$

11. You're performing a hypothesis test for the population mean and you know the population standard deviation.

You plan to sample 60 units from your population and you'd like to use a 1-sided test at a 1% significance level. See attachment with Z-Table & T-Tables for reference.

What is the rejection criteria for this hypothesis test?

Because we know the population standard deviation and we're sampling more than 30 units we can use the normal distribution for your hypothesis test.

Based on the 1-sided test, and 1% significance level, we can look up the Z-value associated with 49.0% of the population, which is Z_{crit} = *~2.33*

12. Which distribution is used to make the accept/reject decision for a hypothesis test for the slope coefficient (β_1) within linear regression:

- Chi-squared distribution
- **T-distribution**
- Binomial distribution
- Normal distribution
- None of the above

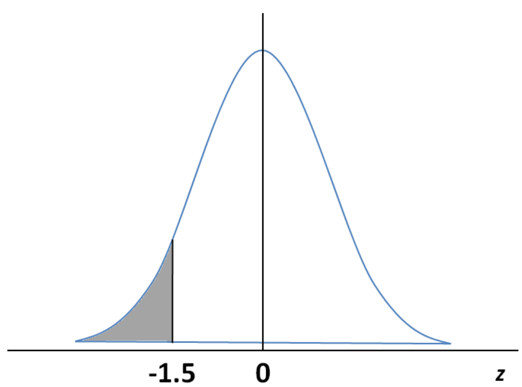
13. Fill in the Blanks: The linear regression method models the relationship between ______A_______ mathematically with _________B_________.

- **A** – Variables
- A –Coefficients
- A – Statistics
- A – Parameters
- B – Statistics
- B – Coefficients
- B – Equations
- B – Parameters

14. A manufacturing operation produces a part that follows the normal distribution with a mean weight of 45 ounces and a standard deviation of 2 ounces. Estimate the percentage of the overall population that would get manufactured less than 42 ounces. Reference the Probability Tables from NIST.

- 57.3%
- 43.3%
- 93.2%
- 6.8%

$$Z = \frac{X - \mu}{\sigma} = \frac{42 - 45}{2} = \frac{-3}{2} = -1.5$$



The probability that Z is between Z = -1.5 is equal to the shaded area above, and can be calculated as 0.50 - 0.43319 which is equal to 6.681%

15. **Fill in the blank: _________________ is the concept that, between trials in an experiment, the results of the 1st experiment do not affect the results of the 2nd experiment.**
    - Constant probability of occurrence
    - Independence
    - Fixed Trials
    - Identical Trials