Midterm Exam 9/11/2013

ID: [illegible]

Section: 10-11

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Q (1: 15 pts) Please state whether each statement is True/False. Please underline the false part then correct it.

1. Quality improvement is the reduction of capability in processes and products. (F) variability
2. Reliability is a critical-to-quality characteristic. (F) Dimension of Quality
3. The upper specification limit is the largest value for the quality characteristic of the product. (T)
4. Acceptance sampling is the least efficient statistical technique for variability reduction. (F) most
5. In Motorola's three-sigma level results in 3.4 parts are defective. (F) 66810? -6
6. Appraisal costs are those costs associated with measuring, evaluating, or auditing products, components, and purchased material. (T)
7. Warranty costs are an example of external production costs. F → (Failure)
8. Training is an example of prevention costs. (T)
9. Box plot is a more compact summary of data than numerical measures. T
10. Histograms are best suited for data sets. (F) large data sets
11. A process that is operating with only assignable causes of variation present is said to be in control. (F) out of control
12. The control charts consists of three parameters; upper control limit, lower control limit, and target. (F) center line
13. Pareto chart is a simple frequency distribution of numerical data arranged by category. (F) attribute/symbol
14. In phase I, trial control charts are established to monitor future production. T
15. Check sheet is a useful plot for identifying a potential relationship between two variables. (F) Scatter diagram

-6

Q (2:10 pts) Please determine the proper probability distribution for the following cases:

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= A quality control engineer collected 50 samples from a lot of 1000 which contains 50 defectives. The probability of finding 4 defective products in the sample is calculated using HyperGeometric distribution.

= A quality control engineer monitors the number of surface defects appear on a white board. The probability of product acceptance can be calculated using poisson distribution.

= The reliability of electronic component with a constant time to failure is of main interest. The probability of component survival a specific number of hours will be estimated using exponential distribution.

= An inspector of welded joints decides to stop inspection when he/she finds the first defective weld. The probability of detecting the first defective weld by the fifth sample will be calculated using Geometric distribution.

= The probability of finding a percentage of broken tubes in a definite sample size is calculated using binomial.

10

Q (2:20 pts) A product is composed of four identical and independent components. Each component is designed with four critical and independent quality characteristics as follows:

product → system

- Weight distributed as **Normally** distributed with mean 30 gm and variance of 9
- Failure density distributed **Exponentially** with mean failure rate of 200 hr.
- Tensile strength distributed as **Weibull** distribution of shape and scale parameters of 0.5 and 200 N, respectively.
- Hardness distributed as **Gamma** distribution of shape and scale parameters of 0.5 and 150 N, respectively.

$\boxed{\beta = 0.5}$ $\boxed{\theta = 200}$

$\boxed{\text{shape parameter} = 2}$ $\boxed{r = 2}$ $\boxed{\lambda = 150}$

(a) For **component's** tensile strength, the specification limits are 105 ± 5, what is the probability that the **product** is rejected?

failure

100 105 110

$1 - P(110 \geq x \geq 100) = P(x \leq 100) + P(x \geq 110)$

$\left(1 - e^{-\left(\frac{100}{200}\right)^{0.5}}\right) + e^{-\left(\frac{110}{200}\right)^{0.5}} =$

$1 - e^{\left(-\frac{1}{4}\right)} + e^{-\frac{11}{40}}$

$= 0.98077$

(b) If the product requires three out of four components operating, what is the probability that the **product** will survive ~~before~~ 205 hr?

Prob that one component will survive after 205 hr

$P(x \geq 205) = e^{-\lambda t} = e^{-0.005 \times 205} = 0.3587$

$\mu = 200$

$\mu = \frac{1}{\lambda}$

$\boxed{\lambda = 0.005}$

Prob that the Product will survive → $\boxed{3 \text{ survive}}$ or $\boxed{4 \text{ survive}}$

Binomial $\binom{4}{3}(0.3587)^3 (1-0.3587) + \binom{4}{4}(0.3587)^4(1-0.3587)^0$

$= 0.1183 + 0.0165 = \boxed{0.13485}$

200 205

(c) What is the probability that the **component**'s hardness exceeds 200 N?

$P(X \geq 200) = \sum_{K=0}^{1} e^{-150 \times 200} \left(\frac{(150 \times 200)^0}{0!} + \frac{(150 \times 200)^1}{1}\right) = \text{zero}$

Reliability

$(\lambda = 150)$

(d) If the product components are arranged in a **standby** redundant configuration, what is the probability that the **product** will survive 150 hrs?

$P(X \geq 150) = \sum_{K=0}^{3} e^{-0.005 \times 150} \left(1 + (0.005 \times 150)^1 + \frac{(0.005 \times 150)^2}{2} + \frac{(0.005 \times 150)^3}{6}\right) =$

$= 0.9927$

$\mu = 200$

$\boxed{\lambda = 0.005}$

Gamma

(f) What is the probability that the **component's tensile strength** exceeds 250 N?

$\beta = 0.5 \quad \theta = 200$

$P(X \geq 250) = e^{\left(-\frac{250}{200}\right)^{0.5}} = e^{-5/8} = 0.5352$

(g) If the product operates if all components operate, what is the probability of product failure?

prob that one component survive after the mean.

$\mu = 200 \text{hr}.$

$P(x \geq 200) = e^{-\lambda t} = e^{-0.005 \times 200} = e^{-1} = 0.3678$

prob that the product operates $(0.3678)^4 = 0.0183$

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Q (3:20 pts) A purchaser adopts acceptance sampling procedure to prevent receiving defective items. The purchaser accepts the lot if at most one defective unit is found.

$P(X \leq 1)$

(a) A lot is composed of 50 units in which 4 defective units are found. A sample of five units is selected. Calculate the probability of lot acceptance.

$N = 50$, $D = 4$, $n = 5$

$50 \to$ 4 defective, 46 non defective

Hyper Geometric

$$P(X \leq 1) = P(X=0) + P(X=1)$$

$$= \frac{\binom{4}{0}\binom{46}{5}}{\binom{50}{5}} + \frac{\binom{4}{1}\binom{46}{4}}{\binom{50}{5}} = \frac{\frac{4!}{0! \times 4!} \times \frac{46!}{5! \times 41!}}{\frac{50!}{5! \times 45!}} + \frac{\frac{4!}{1 \times 3!} \times \frac{46!}{4! \times 42!}}{\frac{50!}{5! \times 45!}}$$

$$\boxed{0.9549} = 0.6469 + 0.3080$$

b) Previous reports reveal that the probability of nonconforming is 0.01, what is the probability that a sample of 5 units contains less than two nonconforming units (infinite population)?

$\boxed{n = 5}$ $(P = 0.01)$

Binomial

$$P(X < 2) = P(X=0) + P(X=1)$$

$$\binom{5}{0}(0.01)^0(1-0.01)^5 + \binom{5}{1}(0.01)^1(1-0.01)^4$$

$$0.9509 + 5 \times (0.01)(0.99)^4$$

$$0.9509 + 0.0480 = 0.9989$$

c) Using proper approximation in part a, calculate the probability of lot acceptance. Is the approximation satisfactory? Why? Why not?

Binomial distribution.

$$\frac{n}{N} < 0.1$$

$$\frac{5}{50} \overset{?}{<} 0.1$$

$$0.1 \overset{?}{<} 0.1 \quad \text{No, it's not satisfactory.}$$

d) Suppose the variance of surface defects on each unit equals 0.01, calculate the probability that a unit contains at least two surface defects?

$\sigma = 0.01$

$\lambda = \sqrt{\sigma}$

$\lambda = \sqrt{0.01}$

$\boxed{\lambda = 0.1}$

$$P(X \leq 2) = P(X=0) + P(X=1) + P(X=2)$$

$$= \frac{e^{-0.1}(0.1)^0}{0!} + \frac{e^{-0.1} \times (0.1)^1}{1} + \frac{e^{-0.1} \times (0.1)^2}{2} =$$

$$0.9048 + 0.0904 + 0.0045 = 0.9997$$

Poisson

e) If the inspector decides to continue sampling till the lot is rejected. What is the probability that he will reject the lot the third samples?

$\boxed{P = 0.01}$

Negative Binomial

$\boxed{r = 3}$

$$P(X > 1) \to = 1 - (P X \leq 1)$$

$$= 1 - [\cancel{\ldots}\ P(X=1)]$$

$$1 - \left[\binom{2}{1}(0.01)^3(1-0.01)^1\right]$$

12

19+12

31/30

The University of Jordan
Department of Industrial Engineering
Quality Control Midterm Exam 9/8/2023

Name: [redacted]
ID: [redacted]

Q (1: 12pts) Please state whether each of the following statements is True/False. Please correct the false underlined part.

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- The control chart only detects chance causes. (False, assinable causes.)
- Scatter diagram is a simple frequency distribution of attribute data arranged by category. (False pareto chart)
- Control charts prevent necessary process adjustment. (False, unnessary)
- The sample standard deviation measures the central tendency of the data. (False, measure Variability.)
- The cause-and-effect diagram is analyzed to determine whether the location of the defects on the unit conveys any useful information about the potential causes of the defects. (False, defect concentration diagram)
- The existence of assignable causes results in a random pattern. (False, nonrandom pattern.)
- The 2-sigma control limits are called the action limits (False Warning limits.)
- A cyclic pattern is a random pattern. (False, non random)
- Check sheet is a useful plot for identifying a potential relationship between two variables. (False, Scatter diagram.)
- In phase I, a set of process data is gathered and analyzed all at once in a retrospective analysis, constructing trial control limits. (True phase I)
- Pareto chart is another way to see the flow of material and information in a process. (False, Value stream mapping.)
- A histogram is a more compact summary of data than a stem-and-leaf plot. (True)
- When the assignable cause affects the process, the product is concluded out of control. (~~True~~ False, process out of control)

8

Q (3: 9 pts) An industrial engineer aims to calculate the probability for the following cases:

(a: 2) A bottle thickness is normally distributed with a mean of 132 gm and a variance of 16. If a sample of size 4 bottles is collected, what is the probability that the average thickness is at most 135 gm?
(Answer: ----------------------

$P(X \leq 135) = P(Z \leq 1.5)$

$P(Z \leq \frac{\bar{X}-\mu}{\sigma/\sqrt{n}})$ $= [0.93319]$

(b: 2) The time-to-failure of a product is **Weibull** distributed with mean and scale parameters of 600 and 100 hrs, respectively. What is the probability that the product survives 90 hr? (Answer: ----------------------

mean = 600

$\theta = 100$

$\frac{600}{100} = \frac{100}{100}(\frac{1}{\beta})!$

$6 = (\frac{1}{\beta})!$

$\frac{1}{\beta} = \frac{1}{3}$

ans is 0.38079

(d: 2) A product is composed of three identical and independent components which are arranged in a standby redundant configuration. The time to failure of each component is exponentially distributed with a mean time to failure of 1000 hours. Calculate the mean time to failure for the product. (Answer: --3000hours.

$m = \frac{1}{\lambda} = \lambda = 1*10^{-3} \to 0.001$

Mean time to failure For product

$= \frac{3}{1*10^{-3}} = 3000$

poisson

(e:2) A control chart is to be established to monitor the number of surface defects on a sheet of fabric. If the mean defect rate = 4 defects /sheet. **Calculate the 2-sigma upper control limit.** answer = 8

$\mu = \lambda$ $\sigma = \sqrt{\lambda}$ $UCL = \mu_w + L\sigma_w$ $L = 2$

$\sigma^2 = \lambda$

$\mu = 4$ $4 + 2(2)$

$\sigma^2 = 4$

$\boxed{UCL = 8}$

$\sigma = 2$

0.6708

sample size Tallen.

3

(f: 2) An industrial engineer monitor the number of nonconforming bottles in a sample size of 100 bottle. The probability of a nonconforming bottle is constant and equal 0.1. Twenty samples are selected. Calculate the LCL of the appropriate control chart. Answer ---------------------

20

Bionomial $\cancel{6 = \boxed{3}}$ $\sigma^2 = 100 * 0.1 * (1-0.1)$ Lower

mean = 10

$LCL = M_w - L\sigma_w$ $\cancel{\frac{3}{\sqrt{20}}}$ $= 7.98$

10 3

1

geometric r=1

(g:2) An inspector decides to continue to checking till finding the first nonconforming bottle. The probability of a nonconforming bottle = 0.1. Calculate the probability that the inspector will check exactly 5 bottles.

$p = 0.1$

$1-p = 0.90$

$p(X=5)$

$p(X=5) = (1-0.1)^{x-1} * p$

$= \boxed{0.06561}$ answer

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The University of Jordan

Industrial Engineering Department

Instructor: ***Prof. Abbas Al-Refaie***

Statistical Quality Control (First Exam **20 %**): 1st 2023/2024

Name: -- *ID*: ------------------

Q1 (10 pts: 15 min) Please state whether each of the following statements is True/False. Please correct the false part.

Statement	Answer/Correction
The cost incurred for materials and services consumed in testing belongs to appraisal costs.	True
The Motorola Six Sigma concept, the ± 3 σ results in 66810 parts per million non-defective.	defectives
Control charts aim to discover the key variables influencing quality characteristics of interest in the process.	Designed experiment
The cost of retesting products that have undergone rework or other modifications is classified as prevention costs.	internal fai costs
The cost of correcting nonconforming units so that they meet specifications is considered a prevention cost.	internal fa
Quality characteristics are often evaluated relative to variability.	specification
Paint containers that are overfilled because of excessive variability in the filling equipment result in quality losses. Yeild	~~internal f~~ / internal f.
The net losses of labor and overhead resulting from defective products that cannot be repaired are prevention costs.	internal fa
DFSS is the set of activities that ensures the quality levels of products and services are properly maintained and that supplier and customer quality issues are properly resolved.	Quality assu
Items in a rejected lot may be reworked or replaced with good units. This is often called ongoing inspection.	rectifying inspection
The "fitness for use" definition has become associated more with the design aspect of quality than conformance.	nonconform more than de
Reliability is a sensory critical-to-quality characteristic.	Time-orient
The cost of preshipment operation of the product to prevent early-life failures in the field is an example of internal failure costs.	prevention costs
In Generation II, Six Sigma focuses on creating value throughout the organization and for its stakeholders.	III
The cost incurred during product design that is intended to improve the overall quality of the product belongs to appraisal quality costs.	prevention costs
GAMs software is used to plot box plots and histograms.	Minitab.

(Q2: 20 min) Please answer the following questions.

(a: 2.5 pts) A random sample of size *n* products was randomly selected from an infinite lot. It is known that the probability that a specific component is conforming = 0.80. If the mean of the distribution = 1. Estimate the probability of finding at least one nonconforming product.

Answer = ---------------------------- ~~0.6723~~ 0.651	Distribution ---- Binomial

① $p = 0.2$ ② $p = 0.1$

$\mu = 1 = np \rightarrow n = 5$

$p(x \geq 1) = 1 - p(x=0) = 1 - \binom{5}{0} p^0 (1-p)^5 = 1 - \left[(1-0.2)^5\right]$

$= 1 - 0.3277 =$

(b: 2.5 pts) A random sample was randomly collected from a production lot. The quality control has decided to continue the inspection process till finding 2 nonconforming units. If the mean of the distribution = 20. Calculate the probability that the inspector inspects exactly 10 units.

Answer = ---------------------------- ~~0.03874~~ 0.0172	Distribution ---- ~~Negative~~ Binomial

① $r = 2$ $x = 10$ ② $r = 3$

$\mu = r/p = 20$ $p = 0.1$

$p(x=10) = \binom{9}{1} p^2 (1-p)^8$ $p(x=10) = 0.017$

$p = 0.1$

$= 9 \times 0.01 \times 0.431 = 0.0387$

(c: 2.5 pts) A production process operates with 2% nonconforming output. Every hour a sample of n units of product is taken, and then the sample fraction defective is calculated. The variance of the distribution = 0.00196. Calculate the probability that the sample fraction defective is at most 0.15.

Answer = ---------------------------- ~~0.98~~ 0.9833	Distribution ---- Binomial

$p = 2\%$ $\boxed{n = 10}$

$\sigma^2 = \frac{p(1-p)}{n} = 0.00196$

$p(\hat{p} \leq 0.15) = p(x \leq 1.5)$ $= 0.98^{10} + 0.2 \times 0.98^9$

$= p(x=0) + p(x=1) = \binom{10}{0} p^0 (1-p)^{10} + \binom{10}{1} p^1 (1-p)^9$

(d: 2.5 pts) An electronic display is subjected to a final functional test. Defects occur randomly at a variance of 0.005 per bottle. Calculate the probability that a display has more than 2 defects.

Answer = ---------------------------- 2.076×10^{-8}	Distribution ---- Poisson

$p(x > 2) = 1 - [p(x=0) + p(x=1) + p(x=2)]$ $\lambda = 0.005$

$= 1 - [1 + e^{-\lambda}] = 1 - [1 + e^{-0.005}] =$