改善
KAIZEN
TEAM

QC

PAst papers

عندما تطمح في شيء وتسعى جادا في الحصول
عليه ..فإن العالم بأسره يكون في صفك
باولو كويلو

25
30

University of Jordan

Dept. of Industrial Engineering
Quality Control (Exam-14-4-11)
Instructor: Dr.Abbas Al-Refaie

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Exam duration: 3:00-5:00

4

Q.(1:4) *Please answer the following questions concisely*

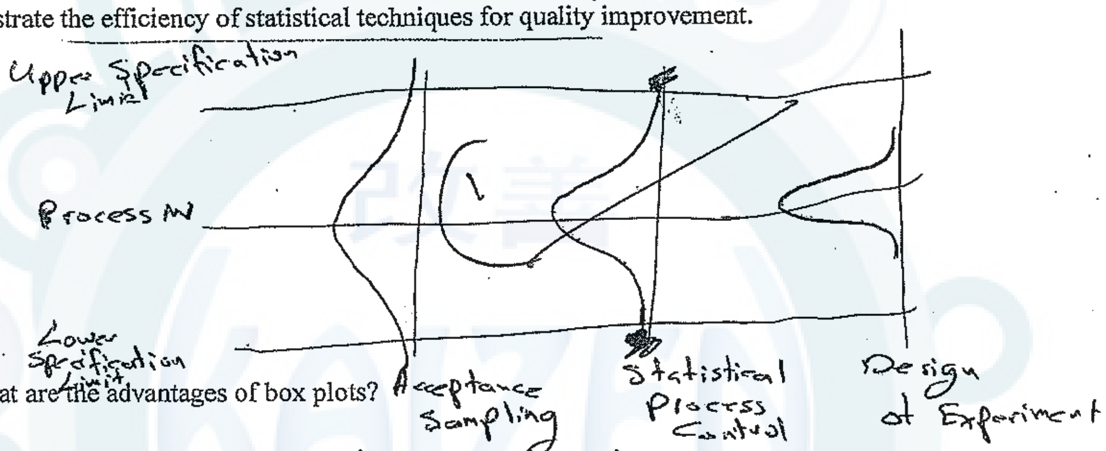
(a) What is the traditional and modern definitions of quality"? How can internal and external costs be disappeared?

Traditional: fitness for use
Modern: ~~inver~~ quality is inversely propotional to variability

Internal costs: ~~**~~ if there were no defects in the product.
External costs: would disappear if every unit of product conformed to requirements.

1

(b) Illustrate the efficiency of statistical techniques for quality improvement.



(c) What are the advantages of box plots?

It's a graphical display that simultaneously displays several important features of the data, such as location of central Tendency, spread of variability, departure from symmetry, identification of observations that lie unusually far from the Data (outliers).

1

(d) What are the limitations of histogram?

1- relatively sensitive to number and width of bins

2- ~~for large (n)~~ Is best used for large data because small (n) it may change dramatically.

3- Doesn't take the ~~time~~ order of the observations into account

1

Q (2:8 pt): An assembly consists of three linkage components normally distributed with means and variances as follows $X_1 \sim N(8, 0.04)$, $X_2 \sim N(5, 0.01)$, $X_3 \sim N(10, 0.09)$. Links are produced by different machines and operators. Assuming these components are produced independently. The final length y is the sum of the three dimensions. Let $\bar{x}_1$, $\bar{x}_2$, and $\bar{x}_3$ denote the averages of components 1, 2, and 3, respectively. Also, let $\bar{y}$ represent the average final length. Use α of 0.05. Please calculate the followings:

6.5

(C.L.T)

$y = \bar{X}_1 + \bar{X}_2 + \bar{X}_3$ $\bar{y}$

(a) What is the probability that the final length falls between 22 and 24?

$y = \bar{x}_1 + \bar{x}_2 + \bar{x}_3 = \cancel{23}$

$\mu_y = \mu_1 + \mu_2 + \mu_3 = 8 + 5 + 10 = 23$

$Z = \frac{X - \mu}{\sigma}$

$\sigma_y^2 = \sigma_1^2 + \sigma_2^2 + \sigma_3^2 = 0.04 + 0.01 + 0.09 = 0.14$

$\therefore \sigma_y = 0.374$

$P(22 \le y \le 24) = P(y \le 24) - P(y \le 22)$

$= P\left(Z \le \frac{24-23}{0.374}\right) - P\left(Z \le \frac{22-23}{0.374}\right)$

$P(Z \le 2.67) - P(Z \le -2.67)$

$0.996207 - 0.003793$

$= 0.992414$

(b) A random sample of 16 assemblies are taken, the average final length, $\bar{y}$, is found 24. Test the hypothesis that mean of the final length is less than 22.5. What is the approximate p value?

$n = 16$, $\bar{y} = 24$, $\alpha = 0.05$

1 population, 1 side

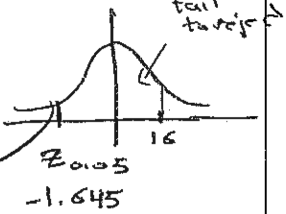
$H_0: \mu = 22.5$

$H_1: \mu < 22.5$

$Z_0 = \frac{\bar{x} - \mu_0}{\sigma/\sqrt{n}} = \frac{24 - 22.5}{0.374/\sqrt{16}} = 16$

2

since $Z_0 > Z_{0.05}$ ∴ fail to reject H_0



P-value is $\Phi(Z_0) = \Phi(16) \approx 0$

(c) A random sample of 25 components are taken, the average length of component 1, $\bar{x}_1$, is found 8.6. Test the hypothesis that the mean is larger than 8.

$n = 25$, $\bar{x}_1 = 8.6$

1 population, 1 sided

$\sigma_1^2 = 0.04 \rightarrow \sigma_1 = 0.02$

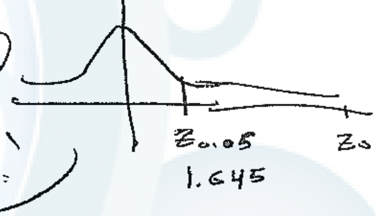
$H_0: \mu = 8$

$H_1: \mu > 8$

$Z_0 = \frac{\bar{x} - \mu_0}{\sigma/\sqrt{n}} = \frac{8.6 - 8}{0.02/\sqrt{25}} = 150$

1

∴ $Z_0 > Z_{0.05}$ ∴ reject H_0



(d) Construct a 95 % two-sided confidence interval on the mean of the first component.

$\alpha = 0.05$ $\frac{\alpha}{2} = 0.025$

$\bar{x}_1 - Z_{\frac{\alpha}{2}} * \frac{\sigma}{\sqrt{n}} \le \mu_1 \le \bar{x}_1 + Z_{0.025} * \frac{\sigma}{\sqrt{n}}$

$8.6 - 1.96 * \frac{0.02}{\sqrt{25}} \le \mu_1 \le 8.6 + 1.96 * \frac{0.02}{\sqrt{25}}$

$8.59 \le \mu_1 \le 8.60784$

1/2

(e) Random samples of 16 and 25 are taken from components 2 and 3, respectively, the averages lengths, $\bar{x}_{2.}$ and $\bar{x}_{3.}$ are measured 4.8 and 9.5, respectively. Can we conclude that the mean of component 3 is exactly two times the mean of component 2.

$n_2 = 16 \quad \bar{X}_2 = 4.8 \quad S_2 = \sqrt{0.01} = 0.1$

$n_3 = 25 \quad \bar{X}_3 = 9.5 \quad S_3 = \sqrt{0.09} \quad 0.3$

$H_0: \mu_3 = 2\mu_2$

$H_1:$

$\bar{x}_1 - \bar{x}_2 - Z_{\frac{\alpha}{2}} * \sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}} \le \mu_1 - \mu_2 \le \bar{x}_1 - \bar{x}_2 + Z_{\frac{\alpha}{2}} * \sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_1}}$

$4.8 - 9.5 - 1.96 * \sqrt{\frac{(0.1)^2}{16} + \frac{(0.3)^2}{25}} \le \mu_1 - \mu_2 \le$

1

3.5

Q(3: 6pts) A system of four diodes connected in a standby mode is studied. The diode failure life is modeled and found exponentially distributed with parameters λ=0.01. Please calculate the followings:

$r = 4$ Gamma

$\left(\mu = \frac{1}{0.01} = \frac{1}{\lambda} = 100\right)$ for 1 component.
$S^2 = 10,000$

(a) What is the probability that the system will fail before 100 hour.

$P(X < 100) \rightarrow 1 - \sum_{M=0}^{3} e^{-(0.01*100)} * \frac{(0.01*100)^M}{M!}$

Gamma: $r = 4$, $a = 100$, $\lambda = 0.01$

1

$= 1 - \left(\left(e^{-1} * \frac{(1)^0}{0!}\right) + \left(e^{-1} * \frac{(1)^1}{1!}\right) + \left(e^{-1} * \frac{(1)^2}{2!}\right)\right)$

$1 - (0.3679 + 0.3679 + 0.18394)$

$= 1 - (0.91974)$

$= 0.083$

(b) Calculate the system mean and standard deviation

$\mu = \frac{r}{\lambda} = \frac{4}{0.01} = 400$

$S^2 = \frac{r}{\lambda^2} = \frac{4}{(0.01)^2} = 40,000 \therefore S = 200$

1/2

(c) Calculate the percentage of diodes that will fail before 100 hour.

$P(X < 100)$ { for all the diodes $\therefore$ Gamma } { if for one diode $\rightarrow$ exponential }

$P(X < 100)$ { like (a) } $\rightarrow = 0.083$

$P(X < 100) = 1 - e^{-0.01*100} = 0.63212$

1

memoryless

(d) If the diode operated for 50 hours. What is the probability that the diode will survive another 100 hours.

Exponential

$P(X > 100) = 1 - P(X \le 100) = 1 - (1 - e^{-\lambda a})$

$= e^{-0.01*100} = 0.3679$

1/2

(e) If the failure rate increases to 0.02 Calculate the diode mean and standard deviation.

Exponential $\rightarrow \mu = \frac{1}{\lambda} = \frac{1}{0.02} = 50$

$S^2 = \frac{1}{\lambda^2} = \frac{1}{(0.02)^2} = 2500 \therefore S = 50$

1/2

(1. / 2 (3) 4)

(f) Suppose that the system is changed to active parallel system in which at least three components should operate to make the system work successfully. Calculate the probability the system will operate 400 hours.

Gama → $P(X=400)$, $r=4$, $\lambda=0.01$

$f(400) = P(X=400) = \frac{\lambda}{\Gamma(r)} * (\lambda x)^{r-1} * e^{-\lambda x} = \frac{0.01}{\Gamma(4)} * (0.01*400)^3 * e^{-(0.01*400)}$

$\Gamma(4) = 3!$

$= 1.66*10^{-3} * 64 * 0.01832$

$= 1.946 * 10^{-3}$

∴ either 3 are working or all of them →

Q(4:4 pt) The variabilities of the service times of two bank tellers are of main interest. A random sample of 9 observations from the 1st teller yields a sample average of 3.4 minutes with a variance of 0.16 minutes. A random sample of 16 observations from the 2nd teller yields a sample average of 2.5 minutes with a variance of 0.25 minutes. Use α of 0.01 to

$s = \sqrt{0.16} = 0.4$ 2 populations $s = 0.5$ $\alpha = 0.05$

$n_1 = 9$, $\bar{X}_1 = 3.4$, $s_1 = 0.4$ | $n_2 = 16$, $\bar{X}_2 = 2.5$, $s_2 = 0.5$

(a) Test the hypothesis that the standard deviation of the service time for the first teller is identical to the standard deviation of the service time for the 2nd teller.

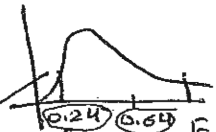
$H_0: \frac{\sigma_1^2}{\sigma_2^2} = 1$

$H_1: \frac{\sigma_1^2}{\sigma_2^2} \neq 1$

F-distribution

$F_0 = \frac{s_1^2}{s_2^2} = \frac{(0.4)^2}{(0.5)^2} = 0.64$

1



F_0 is between $F_{0.025,8,15}$ and $F_{0.975,8,15}$

∴ fail to reject H_0 ∴ $\frac{\sigma_1^2}{\sigma_2^2} = 1$ ∴ $\frac{\sigma_1}{\sigma_2} = 1$

$F_{0.025,8,15} = 3.2$ $(F_{0.025})$, $F_{0.975,8,15} = \frac{1}{F_{0.025,15,8}} = \frac{1}{4.1} = 0.2$

(b) Test the hypothesis that the service time for the first teller is greater than the service time for the 2nd teller by one. Assume equal variances.

$H_0: \mu_1 - \mu_2 = 1$

$H_1: \mu_1 - \mu_2 > 1$

t-distribution case ① for cause equal $\sigma_1 = \sigma_2$

∴ $s_p^2 = \frac{(n_1-1) * s_1^2 + (n_2-1) * s_2^2}{n_1+n_2-2}$

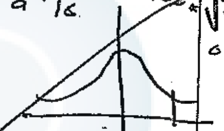
$s_p^2 = \frac{8*(0.4)^2 + 15*(0.5)^2}{9+16-2} = 0.22$

∴ $s_p = 0.468$

$t_0 = \frac{\bar{X}_1 - \bar{X}_2 - \Delta}{s_p * \sqrt{\frac{1}{9}+\frac{1}{16}}} = \frac{3.4 - 2.5 - 1}{0.468 * \sqrt{\frac{1}{9}+\frac{1}{16}}}$

0.193

$t_0 = -0.513$



$t_0 < t_{0.05,23}$ ∴ fail to reject H_0

$t_{0.05,23}$ 1.714

(c) Construct a 95 % upper confidence interval on the mean of the 2nd teller.

1 population

$\mu_2 \leq \bar{X} + t_{0.05,15} \frac{s}{\sqrt{n}}$ ($t_{\alpha,n-1}$)

$\mu_2 \leq 2.5 + 1.753 * \frac{0.5}{\sqrt{16}}$

$\mu_2 \leq 2.72$

1

(d) Construct a 95% lower confidence interval on the variance of the service time of the 1st teller.

$$\frac{(n-1)*S_1^2}{\chi^2_{0.05,(n-1)}} \le \sigma^2$$

$$\frac{8*(0.4)^2}{\cancel{16.92}} \le \sigma^2 \longrightarrow 0.07565 \le \sigma^2$$

15.51

1/2

Q(5:2 pt) Consider a lot of 100 parts, of which 10 are nonconforming. If a sample of 10 parts is selected, what is the probability of obtaining 2 nonconforming items? Use a proper approximation to calculate the required probability? Check whether the approximation is satisfactory or not?

N = 100, D = 10, n = 10, X = 2

From Hypergeometric to Binomial $P(x) = \binom{n}{x} p^x (1-p)^{n-x}$

$\frac{n}{N} \overset{?}{<} 0.1 \rightarrow \frac{10}{100} \overset{?}{<} 0.1 \rightarrow 0.1 = 0.1$ ∴ not ~~satisfactory~~

$P = \frac{D}{N} = 0.1 \rightarrow P(X=2) = \binom{10}{2}(0.1)^2 * (1-0.1)^8$

$= \frac{10!}{2! * 8!} * (0.1)^2 * (1-0.1)^8 =$

$= 0.194$

1.1/2

Q (6:2 pt) A company is interested in determining whether the proportions of nonconforming items are unequal for two of its vendors. A random sample of 200 items from the 1st vendor revealed 10 nonconforming items. A random sample of 300 items from the 2nd vendor showed 15 nonconforming items. Construct a 90 % confidence interval on the difference between the two proportions.

$n_1 = 200$, $X_1 = 10$, $\hat{p}_1 = \frac{X_1}{n_1} = 0.05$

$n_2 = 300$, $X_2 = 15$, $\hat{p}_2 = 0.05$

$\alpha = 0.1$, $\frac{\alpha}{2} = 0.05$

$\hat{p} = \frac{X_1 + X_2}{n_1 + n_2} = 0.05$

$$\hat{p}_1 - \hat{p}_2 - Z_{0.05} * \sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}} \le P_1 - P_2 \le$$

$$0.05 - 0.05 - 1.645 * \sqrt{\frac{0.05(1-0.05)}{200} + \frac{0.05(1-0.05)}{300}} \le P_1 - P_2 \le 0.05 - 0.05 + 1.645 \sqrt{\frac{(0.05)(1-0.05)}{200} + \ldots}$$

$$-0.033 \le P_1 - P_2 \le 0.033$$

(7:2 pt): The time to failure for a cathode ray tube can be modeled using a Weibull distribution with parameters β = 1 and θ = 200 hours. What is the probability of a tube fail at before 800 hours?

$$P(X < 800) = 1 - \exp\left[-\left(\frac{800}{200}\right)^1\right] = 1 - \exp(-4)$$

$$= 1 - 0.0183$$

$$= 0.98168$$

$1 - \exp\left[-\left(\frac{x}{\theta}\right)\right]$

2

Q(8:2pt) A lightbulb has a normally distributed light output with mean 5,000 end foot-candles and standard deviation of 50 end foot-candles. Find the lower specification limit such that only 0.5 % of the bulbs will not exceed the limit.

$\mu = 5000$, $\sigma = 50$

$P(Z < LSL) = 0.005$, $1 - 0.005 = 0.995$

$\frac{\mu - LSL}{\sigma}$, $\frac{x-\mu}{\sigma}$

$2.575 = \frac{5000 - LSL}{50}$

LSL = 4871.25

2

[redacted]

[redacted]

University of Jordan

Dept. of Industrial Engineering

Quality Control (Mid-Exam-28-11-2011)

Instructor: Dr.Abbas Al-Refaie *

23.5 / 30

3.5

Q (1: pt 4) ***Please fill the blank with proper terms or statements.***

- Quality is inversely proportional to ---Variability---.
- ---Appraisal costs--- are those costs associated with measuring, evaluating, or auditing products, components, and purchased material to ensure conformance to the standards that have been imposed.
- The situation in which the probability of producing a product within specification limits is 0.9973 is referred to as ---Three sigma quality performance
- Testing incoming material belong to ---Appraisal--- costs.
- Quality planning and training belongs to ---Prevention--- costs.
- Warranty adjustment belongs to ---External faluire--- costs.
- Internal scrap and rework belong to ---internal faluire--- costs.
- The most effective statistical technique for reducing variability is ---Design of Experiments---.
- Assignable cause may result on ---Change material--- ~~and~~/or ~~X~~ Change Tool---.
- Histogram requires ---large--- data, and ignores ~~X too~~ few bins---.
- A good estimator should be ---Unbiased--- and has ---minimum Variance

-3

1

Q (2: 4pts): Two technicians perform the same drilling operation. A random sample of 12 from the first technician gives an average machining time of 3.5 minutes with variance 0.9 minutes. A random sample of 10 from the second technician yields an average machining time of 4 minutes with variance of 0.25 minutes. Use $\alpha = 0.05$, test the hypothesis that the operator's means are equal. Assume equal variances.

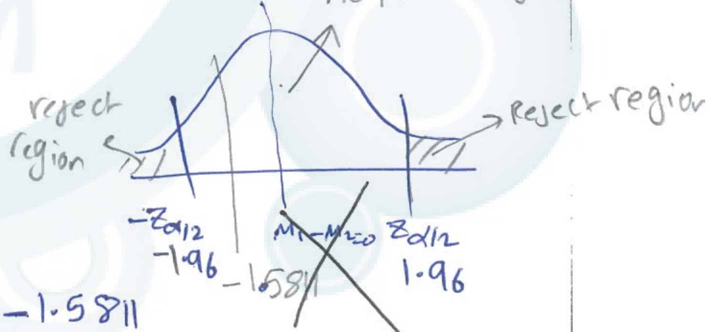
$n_1 = 12$, $\bar{X}_1 = 3.5$, $\sigma_1^2 = .9$

$n_2 = 10$, $\bar{X}_2 = 4$, $\sigma_2^2 = .25$, $\alpha = .05$

Variance are known

$H_0: M_1 - M_2 = 0$

$H_1: M_1 - M_2 \neq 0$



$$Z_0 = \frac{(\bar{x}_1 - \bar{x}_2) - (M_1 - M_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} = \frac{(3.5 - 4) - 0}{\sqrt{\frac{.9}{12} + \frac{.25}{10}}} = -1.5811$$

Fail to reject Ho

$\therefore M_1 - M_2 = 0$

Q (3: 6 pts): The time to process purchase orders is normally distributed. A random sample of 16 orders is selected. The average processing time is found to be 9 days with a standard deviation of 2.2. Use α of 0.05

$n = 16$
$\bar{X} = 9$
$S = 2.2$
$\alpha = .05$

a- Can you conclude that the standard deviation is larger than 2.

~~$H_0: \sigma_1^2 = \sigma_2^2$~~

~~$H_1:$~~

$H_0: \sigma_1^2 = 4$

$H_1: \sigma_1^2 > 4$

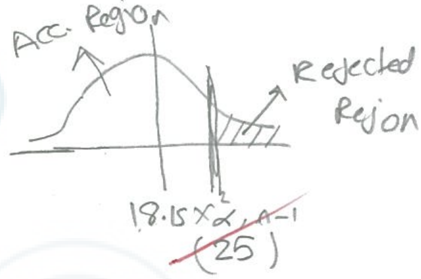
6

$$X_2 = \frac{(n-1)S^2}{\sigma^2} = \frac{15(2.2)^2}{4} = 18.15$$

fail to reject Ho

$\therefore \sigma_1^2 = 4$

No, can't Conclude.



c- Find the upper 90 % confidence interval for the mean of the order processing times.

$\boxed{1-\alpha = .9}$

$\boxed{\alpha = .1}$

$$P\left(\bar{X} + t_{\alpha, n-1} \, S/\sqrt{n} \geq M\right) = (1-\alpha) .9$$

$$P\left(9 + t_{.1, 16} \, 2.2/\sqrt{16} \geq M\right) = .9$$

$$\left(9 + 1.341\left(\frac{2.2}{\sqrt{16}}\right) \geq M\right) \longrightarrow (9.73755 \geq M)$$

Q (4: 6 pts) A new purification unit is installed in a chemical process. Before its installation, a random sample of size = 25 yielded the following data about the percentage of impurity average of 22 and variance of 5. After installation, a random sample of size = 16 resulted in average of 16 and variance of 4. Use α = 0.05

$n_1 = 25$ $\quad n_2 = 16$
$\bar{X}_1 = 22$ $\quad \bar{X}_2 = 16$
$\sigma_1^2 = 5$ $\quad \sigma_2^2 = 4$

(a) Test the hypothesis that the two variances are equal.

4

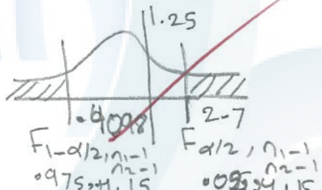
$H_0: \sigma_1^2 = \sigma_2^2$

$H_1: \sigma_1^2 \neq \sigma_2^2$

$$F_0 = \frac{S_1^2}{S_2^2} = \frac{5}{4} = \boxed{1.25}$$

$$F_{1-\alpha/2, n_1-1, n_2-1} = \frac{1}{f_{\alpha/2, n_2-1, n_1-1}} = \frac{1}{2.44} = .4098$$

$\quad\quad 15 \quad 24$



Fail to reject Ho $\quad \therefore \sigma_1^2 = \sigma_2^2$

(b) Can you conclude that the both purification devices have the same mean percentages of impurity.

Variances known

$H_0: M_1 - M_2 = 0$

$H_1: M_1 - M_2 \neq 0$

$$Z_0 = \frac{(\bar{X}_1 - \bar{X}_2) - \Delta_0}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} = \frac{(22-16) - 0}{\sqrt{\frac{5}{25} + \frac{4}{16}}} = \boxed{8.944}$$

reject Ho $\longrightarrow$ Purifications don't have same mean

(c) Construct the upper 90 % confidence interval on variance of old purification unit.

$$\left(\frac{(n-1)S_1^2}{X^2_{1-\alpha, n_1-1}} \geq \sigma_1^2\right) = .9$$

$$\left(\frac{(25-1) * 5}{X^2_{.9, 24}} \geq \sigma_1^2\right)$$

$$\left(\frac{24 * 5}{15.66} \geq \sigma_1^2\right) \longrightarrow (7.6628 \geq \sigma_1^2)$$

Q (5: 3 pts) A valve is produced in lots of size 36. An acceptance testing procedure consists of selecting 9 components at random from the lot without replacement and testing them. If two or more nonconforming components are found, the lot is rejected. If the lot contains four nonconforming components, calculate the desired probability using binomial approximation. Is this approximation satisfactory? Why or why not?

3

$N = 36$
$n = 9$
$D = 4$

(n, P)

$\boxed{P = D/N} = 4/36 = .11$

reject $x \geq 2$

$P(X \geq 2) = \binom{n}{x} p^x (1-p)^{n-x}$

$= 1 - P(X < 2)$

$= 1 - [P(X=0) + P(X=1)] \Longrightarrow 1 - \left[\binom{9}{0}(.11)^0(.89)^9 + \binom{9}{1}(.11)^1(.89)^8\right]$

$1 - [.350356 + .389723] = \boxed{.259921}$

??

$\frac{n}{N} < .1$

??

$\frac{9}{36} < .1$

$\frac{9}{36} = .25$

$\therefore$ the Approx. not satisfac because the Condition of Approximation not accur

Q (6: 7 pts): The time to failure for a cathode ray tube can be modeled using a Weibull distribution with parameters $\beta = 1$ and $\theta = 300$ hours.

4

(a) What is the probability of a tube failing before 800 hours?

because $\beta = 1$ → so weibull convert to exponential dis

$\lambda = \frac{1}{\theta} = \frac{1}{300}$

1

$P(X \leq 800) = 1 - e^{-\lambda a} = 1 - e^{-\frac{1}{300} * 800} = 1 - .06948 = .930517$

(b) What is the probability that the tube will survive 300 hours?

$P(X \geq 300) = e^{-\lambda a} = e^{-\frac{1}{300} * 300} = .367879$

1

(c) Suppose a system is built using three identical tubes in a standby redundant system, what is the probability that the system will survive 500 hours.

⟹ convert to gamma

$r = 3$

$\lambda = \frac{1}{300}$

$P(X = 500) = \sum_{k=0}^{(r-1)=2} \frac{e^{-\lambda a}(\lambda a)^k}{k!}$

2

$= k=0 + k=1 + k=2 \Longrightarrow$

$e^{-\frac{1}{300}*500}\frac{\left(\frac{1}{300}*500\right)^0}{0!} + e^{-\frac{1}{300}*500}\frac{\left(\frac{1}{300}*500\right)^1}{1!} + e^{-\frac{1}{300}*500}\frac{\left(\frac{1}{300}*500\right)^2}{2!} = .18887 + .3148 + .2623 = \boxed{.76597}$

(d) Assume the system in **part c** can operate with at least 2 tubes, what is the probability of system operation? (hint, use the result of part b)

$r \geq 2$

$P(r \geq 2) = 1 - P(r < 2)$

$1 - .76597 = .23403$

QC 2011- 2012

QC

Q (1:10 pts) Please state whether the following is true or false (T/F), underline the false part then correct it:

1. How easy it is to repair the product? refers to durability. (X) Servicability
2. The sensitizing rules are also called the zone rules. (X) the Western Electric rules
3. Traditional definition of quality is fitness for use. (✓) ---------
4. Taste and appearance are examples of sensory critical-to-quality characteristics. (✓) ---------
5. Design of experiment technique is the most efficient tools in reducing variability. (✓) ---------
6. Product inspection and test is an example of appraisal costs. (✓) ---------
7. Liability is an example of external failure costs. (✓) ---------
8. Prevention costs are those associated with efforts in design and manufacturing that are directed toward the prevention of nonconformance. (✓) ---------
9. In statistical six-sigma, the fraction nonconforming is 0.002 ppm. ~~(X)~~ --------- defective ✓ ~~defective~~ 2
10. A histogram is more compact summary of data than a stem-and-leaf plot. (✓) ---------
11. The box-plot is a graphical display that simultaneously several important features (location, spread, etc) of the data. (✓) ---------
12. The control limit contains target and two control limits. (X) control chart - CL → (control chart, center line (CL))
13. The specification limits are used to decide about product acceptance or rejection. (✓) ---------
14. There is no mathematical relationship between specification limits and control limits. (✓) ---------
15. The rational subgroup concept means that the chance for differences between subgroups will be maximized, while the chance for differences within subgroup will be minimized. (✓) ---------
16. Random sampling is performed by taking each sample of units of product that are representative of all units that have been produced since the last sample was taken. (✓) ---------
17. A run of length eight or more points has a very low probability of occurrence in a random sample of points. (✓) ---------
18. Check sheet is simply a frequency distribution of attribute data arranged by category. (X) Pareto chart.
19. The defect concentration diagram is analyzed to determine whether the location of the defects on unit conveys any useful information about the potential causes of the defects. (✓) ----------------------
20. A process operating under the existence of assignable causes is said to be out-of-control. (✓) ---------

10

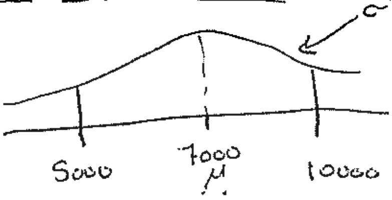
The life $\sim N(7000, (1000))$

$\mu = 7000$

Q (4: 4 pts) The specification on an electronic component in a target-acquisition system are that life is must be between $\boxed{5{,}000}$ and $\boxed{10{,}000}$ hr. The life is normally distributed with mean 7000. The manufacturer realizes a price of \$ 10 per unit processed. However, defective units must be replaced at a cost of \$ 5 to the manufacturer. The standard deviation is 1000 hr.

$np = 7000$ $\sigma^2 = 1 \times 10^6$

- Calculate the expected profit when $\boxed{5{,}000}$ are sold. $\boxed{n = 5000}$



$10 \times 5000 = \$50\,000$

$P(X \leq 5000)$

$P(Z \leq -2)$

$= 0.02275$ the prop to be defective.

$50\,000 - 568.75$

$= \boxed{4431.25}$ the expected profit

$\Rightarrow 5000 \times 0.02275 = 113.75 \Rightarrow$ may be ~~were~~ defective

so $5 \times 113.75 = 568.75$

1/2

- If a sample of 40 units are selected with the same mean and standard deviation. What is the probability that mean life will exceed 10, 000?

$n = 40$ μ & σ are the same.

$P(X > 10000) = 1 - P(X \leq 10000) = 1 - P\left(Z \leq \frac{10\,000 - 7000}{1000}\right)$

$= 1 - P(Z \leq 3) = 1 - 0.99865 = 1.35 \times 10^{-3} = 0.00135$ #

Q (5: 5 pts) A system is composed of $\boxed{4}$ electronic $\boxed{\text{units}}$ that are exponentially distributed with mean life to failure of 500 hours. $\boxed{r = 4}$ $\boxed{\mu = \frac{1}{\lambda} = 500}$ $\boxed{\lambda = \frac{1}{500} = 0.002}$

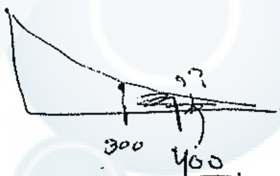
- What is the probability the $\boxed{\text{unit}}$ will fail before its 500 hours. use expo. dist.

$F(a) = F(500) = 1 - e^{-\lambda(500)}$ a.

$= 1 - e^{-0.002(500)} = 0.63212$.

- What is the probability that the unit will operate 400 if it operated 300 hours.

$F(a) = F(400) = 1 - e^{-0.002(400)} = 0.5507$.



- What is the probability that the system will survive $\boxed{500}$ hours if the units are arranged in a stand-by configuration? use Gamma dist. $\boxed{r = 4}$ $\lambda = 0.002$

3/

$R(500) = \sum_{k=0}^{4-1} e^{-(0.002)(500)} \frac{[(0.002)(500)]^k}{k!}$

??

$= \frac{e^{-1}(1)^0}{0!} + \frac{e^{-1}(1)^2}{2!} + \frac{e^{-1}(1)^3}{3\ 2!} = 0.3679 + 0.18395 + 0.122$

?? ??

28.5

University Of Jordan
Industrial Engineering Department
Quality Control (Mid-term, 27-11-2010)
Instructor: Dr. Al-Refaie, Abbas

4.5

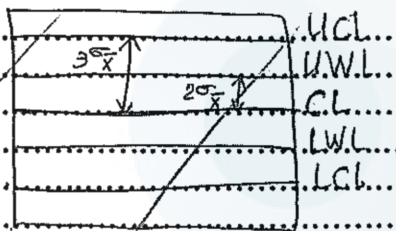
Student Name: ..[redacted].. Section: ..9-10.. ~~8:32~~

Q1. (10) Please state whether each of the following statements is True or False (if false, please correct it).

1. The control chart detects assignable and chance causes. (---False (only assignable)
2. A product is considered defective if it contains one or more minor nonconformities. (----------------------
3. Quality is directly proportional to variability. (---False (inversly)---
4. When six-sigma is used, the fraction nonconforming is 3.4 ppm. (---True-------
5. Length and hardness are examples of sensory quality characteristics. (---False (physical)
6. Internal failure happens when a product fails to operate successfully. (---False (External)
7. Inspection and test of incoming material is an example of prevention costs. (---false (Appraisal)
8. SPC reduces variability more than design of experiment. (---True-------
9. SPC is based on sound underlying principles and can only be applied to industrial processes. (---True---
10. Fitness for use is the modern definition of quality. (---False (traditional)
11. Specification limits are the parameters of the control chart. (---True-------
12. Aesthetics is "What is the reputation of the company or its products? "(----------------------
13. The Histogram is simply a frequency distribution of attribute data arranged by category. (---True
14. The defect concentration is a formal tool frequently useful in underlying potential causes. (---True
15. The scatter diagram is a useful plot for identifying a potential relationship between two variables. (---True
16. A process operating in the existence of assignable causes is said to be in-control. (---False (out of control)
17. Control charts are used to improve the process and estimating specification limits. (---True---
18. When a process is operating properly, an out-of-control action plan should be done. (---True---.
19. SPC is effective in eliminating variability. (---True---
20. Stem and leaf displays the three quartiles, the minimum, and the maximum of the data on a rectangular box. (---False (box plot)

Q (2) Illustrate the difference between the warning limits and action limits on a control chart? **(3 pts)**

3



$UCL = \mu_w + 3\sigma$
$LCL = \mu_w - 3\sigma$
$CL = \mu_w$
$UWL = \mu_w + 2\sigma$
$LWL = \mu_w - 2\sigma$

7.5

Q (3): Three identical components are arranged in a standby redundant system. If the useful life of each component is described by an exponential distribution with mean failure rate of 300 hr. Please answer the followings: **(10 pts)**

$\frac{1}{\lambda} = 300$

a- Write down the density function for the useful life of the system. **(2 pts)** $\Rightarrow \lambda = 0.003$

exponential $\boxed{f(x) = \lambda e^{-\lambda x}}$

b- What is the probability that a component will fail before 250 hr? **(2 pts)**

$P(X \le a)$

$P(X \le 250) = 1 - e^{-\lambda a} = \cancel{\ldots} =$

$= 1 - e^{-0.003 \times 250} = 1 - 0.472 = 0.528$

c- What is the probability that the system will survive more than 600 hrs? **(3 pts)**

P to survive = 1 − P to failure

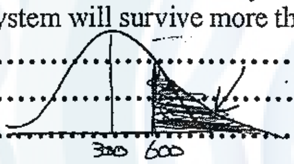
$P(X \le 600) = 1 - e^{-0.003 \times 600} = 1 - 0.165 = 0.835$

$\Rightarrow$ prob. to survive $= 0.165$

d- If the useful life of the system is approximately described by a normal distribution, what is the probability that the system will survive more than 600 hrs? **(3 pts)**

$N(\mu, \sigma^2)$

$N(300, \ldots)$



$P(X \ge 600) = 1 - P(X \le 600)$

Standarization $\Rightarrow$

$1 - \Phi\left(\frac{X - \mu}{\sigma}\right) = 1 - \Phi\left(\frac{600 - 300}{\ldots}\right)$

$= 1 - \Phi(0.9) = 1 - 0.815$

$= 0.18406$

Probability of survive $= 0.18406$

Q (4): A system consists of three modules A, B and C connected ~~in series~~. The time to failure of module **A** follows a Weibull distribution with scale parameter θ = 100 hours and β = 3.2. The time to failure of module **B** follows the normal distribution with mean μ = 400 cycles and standard deviation σ = 32 cycles. It was also noted that during 1 hour, module **B** performs 12 cycles. Find the probability that the system will survive up to 240 cycles of module **B**. **(4 pts)**

per unit

A — B — C

Weibull: $\theta = 100$, $\beta = 3.2$

normal: $\mu = 400$, $\sigma = 32$

Q(5) The filling of glass bottles with a soft-drink beverage can be performed on two machines. The filling processes have known standard deviations of 0.03 and 0.02 liters, respectively. A random sample of 25 bottles is taken from the production of the first machine, where as a sample of 20 bottles is selected from the second machine. The averages of net weight are 2.6 and 2.8 liters, respectively. Please answer the followings: **(5pts)**

a- What are the quality characteristic and its type?

filling of glass (weight) ⇒ physical quality characteristic

b- Test the hypothesis that both machines fill the same net contents, using **α = 0.05.**

2- populations ⇒ test on mean difference & variances known.

$H_0: \mu_1 - \mu_2 = 0$ $\quad Z_0 = \frac{\bar{X}_1 - \bar{X}_2 - \Delta_0}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$ $\Rightarrow Z_0 = \frac{2.6 - 2.8}{\sqrt{\frac{0.03^2}{25} + \frac{0.02^2}{20}}}$

$H_1: \mu_1 - \mu_2 \neq 0$

$\Rightarrow Z_0 = \frac{-0.2}{7.5 \times 10^{-3}} = 26.66$

5

⇒ reject H_0

⇒ All same net contents

c- Calculate the *P*-value for the test.

$P\text{-value} = 2[1 - \Phi|Z_0|]$

Q (6): Two operators perform the same machining operation. Their supervisor wants to estimate the difference in the mean machining times between them. A random sample of 10 from the first operator gives an average machining time of 4.6 minutes with a standard deviation of 0.4 minutes. A random sample of 8 from the second operator yields an average machining time of 5.4 minutes with a standard deviation of 0.5 minutes. Use α=0.05. **(10 pts)**

$n_1 = 10$ $\quad n_2 = 8$

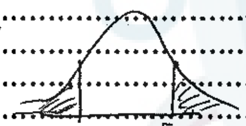
$\bar{X}_1 = 4.6$ $\quad \bar{X}_2 = 5.4$

$S_1 = 0.4$ $\quad S_2 = 0.5$

a- Test the hypothesis that the two variances are equal. (4pts)

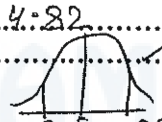
$H_0: \sigma_1^2 = \sigma_2^2$ $\quad \boxed{F_0 = \frac{S_1^2}{S_2^2}} \Rightarrow \frac{0.4^2}{0.5^2} \Rightarrow F_0 = 0.64$

$H_1: \sigma_1^2 \neq \sigma_2^2$



$F_{0.025, 9, 7} = 4.82$ $\quad F_{0.975, 9, 7} = \frac{1}{4.82} = 0.21$

4



fail to reject H_0

b- If the mean machining time of the second operator should be exceed the mean of the first operator by 0.6. Can we support this hypothesis? (4 pts)

$\mu_2 - \mu_1 = 0.6$ $\quad \sigma_1^2 \neq \sigma_2^2$

c- Find a 95% lower confidence interval for the mean machining times of the second operator. (2pts)

9

Q (7): The variability of the time to be admitted in a health care facility is of concern. A random sample of 15 patients shows a mean time to admission of 2.2 hours with a standard deviation of 0.2 hours. **(5 pts)**

a- Can we conclude that the variance of time to admission is less than 0.06 at α of 0.01?. **(3pts)**

1-pop

$n=15$ $\bar{x}=2.2$ $s=0.2$

$H_0: \sigma^2=0.06$ $\alpha=0.01$

$\sigma^2 < 0.06 \Rightarrow \chi^2_{1-\alpha,14} = 4.66$

$\chi^2_{0.01,14} = 29.14$

$\boxed{\chi^2_0 = \frac{(n-1)s^2}{\sigma_0^2}} = \frac{14 \times 0.2^2}{0.06}$

$\chi^2_0 = 155.55$

1.5 should χ^2_0

4.66 29.14 $\chi^2_0 \Rightarrow$ (reject H_0) fail to $\Rightarrow$ No we can't conclude

b- Find a 95% lower confidence interval for the mean ~~machining times of the second operator~~. (2pts)

$\alpha=0.05$

$\boxed{\bar{x} - t_{\alpha,n-1}\frac{s}{\sqrt{n}} \leq \mu} \Rightarrow \mu \geq 2.2 - 1.761 \frac{\times 0.2}{\sqrt{15}}$

2

$\mu \geq 2.1$

Q (8): Two operators perform the same machining of applying a plastic coating to Plexiglas. We want to estimate the difference in the proportion of nonconforming parts produced by the two operators. A random sample of 100 parts from the first operation shows that there are 6 nonconforming. A random sample of 200 parts from the second operator shows that 8 are nonconforming. Use $\alpha = 0.01$ (5 pts)

$n_1=100 \to 6$ non

$n_2=200 \to 8$ non

a- Can we conclude that the difference in the proportion of nonconforming parts produced by the two operators is greater than 0.018?.

$\boxed{\hat{p}=\frac{x}{n}} \Rightarrow \hat{p}_1 = \frac{6}{100} = 0.06$, $\hat{p}_2 = \frac{8}{200} = 0.04$

2-pop:

$H_0: \hat{p}_1 - \hat{p}_2 = 0.018$

$H_1: \hat{p}_1 - \hat{p}_2 > 0.018$

$z_0 = \frac{\hat{p}_1-\hat{p}_2 - ?}{\sqrt{\hat{p}(1-\hat{p})\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}} = \frac{0.018}{\sqrt{0.0176(0.015)}}$ 2.64×10^{-4}

$= \frac{0.018}{0.0162}$

1

$\Rightarrow$ reject H_0

one sided

z_α 0.50399

$z_0 = 1.11$

b- Test the hypothesis whether the proportion of nonconforming for second operator is equal to 4.5%.

$p_2 = 0.045$

$p_2 \neq 0.045$

$z_0 = \frac{(x+0.5)-np_0}{\sqrt{np_0(1-p_0)}} = \frac{(8+0.5)-9}{\sqrt{9 \times (1-0.045)}}$

$8<9$ np_0

1.5

2-sidded

$= \frac{-0.5}{2.93} = -0.17$

$z_{\alpha/2}$

c- Calculate the *P*-value for the test in part (b).

$P_{value} = 2[1-\phi|z_0|]$

Q (9) Consider a lot of 100 parts, of which 3 are nonconforming. A sample of 4 parts is selected, if approximation is used, what is the required probability of obtaining at most one nonconforming item? Is this approximation satisfactory? (3pts)

$N=100 \to 3$ non $n=4$ (hyper geometric $\to$ bin

$P(X\leq 1) = P(x=0)+P(x=1)$ condition $\frac{n}{N} \leq 0.1 \Rightarrow 0.04 \leq 0.1$ satisfa

3

$= \binom{4}{0}(0.03)^0(1-0.03)^4 + \binom{4}{1}(0.03)^1(1-0.03)^3$ $p=\frac{D}{N}=\frac{3}{100}=0.03$

$=$ ~~0.027~~ ~~0.12~~ 0.1

$B(n,p) = B(4, 0.03)$

$P(x) = \binom{n}{x} p^x (1-p)^{n-x}$

$= 0.88 + 0.1$

$= 0.99$

9

University of Jordan
Dept. of Industrial Engineering
Quality Control Quiz-28-12-2011)
Instructor: Dr. Abbas Al-Refaie

Name: [redacted] Reg. No. [redacted] Section: 11-12:30

Q.(1:10 pts) Given the following (assume normally distributed quality characteristic):

***(i)* The $\bar{x}$ - R charts:**

- The $\bar{x}$ chart: CL = 625 UCL= 640 LCL= 610 $n = 9$
- The R chart: CL= 8 UCL = 16 LCL= 0

The specifications on the product were 620±8,

6

(a) Estimate the mean and standard deviation. If the sample size is changed to three, construct the *R*- chart.

$$\text{Mean} = \bar{\bar{x}} = CL = \boxed{625}$$

$$\text{Standard deviation} = \bar{R}/d_2 \quad , \bar{R} = CL = 8 \qquad d_{2\,n=9} = 2.970$$

$$= \boxed{2.6936}$$

1x

$n_{old} = 9$

$n_{new} = 3$

$$UCL = D_4 \left[\frac{d_2\ new}{d_2\ old}\right] \bar{R}_{old} = 2.574 \left[\frac{1.693}{2.97}\right] * 8 = \boxed{11.738}$$

$$CL = \left[\frac{d_2\ new}{d_2\ old}\right] \bar{R}_{old} = \left[\frac{1.693}{2.97}\right] * 8 = \boxed{4.5603}$$

b) Calculate the process capability index.

$$LCL: \left[\max\{0, D_3 \left(\frac{d_2\ new}{d_2\ old}\right] \bar{R}_{old} = \text{Zero} \left[\frac{1.693}{2.97}\right] * 8 = \boxed{\text{Zero}}$$

2

$$\text{Process Capability} = \frac{USL - LSL}{6\sigma} \qquad USL = 628, \ LSL = 612$$

$$\sigma = \bar{R}/d_2 = 8/2.97 = 2.6936$$

$$= \frac{628 - 612}{6 * 2.6936} = \boxed{0.99}$$

(c) What is the probability of detecting a shift in the process mean to 640 by the third subsequent sample following the shift?

$$\text{Probability of detecting} = \beta^i (1-\beta) = 1^i (1-1) = \boxed{\text{Zero}}$$

shift to 640 & Mean = 640

$$\boxed{\beta = 1}$$

KAizen Team

الإجابة في الخلف

University of Jordan

Dept. of Industrial Engineering

Quality Control (Mid-Exam-26-7-09)

Instructor: Dr.Abbas Al-Refaie

PLEASE PROVIDE FINAL ANSWERS WITH DETAILED CALCULATIONS AND EQUATIONS

Q.(1:23) *Please fill the blank with proper terms or statements.*

23

- Variability is inversely proportional to (--1--).
- (--2-) increase the sensitivity of the control charts and result in false alarm of out-of-control.
- The situation in which the probability of producing a product within specification limits is 0.9973 is referred to as (--3---).
- (--4--) are those costs associated with measuring, evaluating, or auditing products, components, and purchased material to ensure conformance to the standards that have been imposed.
- (--5--) is a more compact summary of data than a (--6--).
- The (--7--) is a graphical display that simultaneously displays several important features, such as location or central tendency, spread or variability.
- (-8--) is a graphical method for determining whether sample data conform to a hypothesized distribution based on a subjective visual examination of the data.
- The (--9--) is the smallest level of significance that would lead to rejection of the null hypothesis.
- (--10--) is a powerful collection of problem-solving tools useful in achieving process stability and improving capability through the reduction of variability.
- The process that is operating in the presence of assignable causes is said to be (--11--).
- (--12--) is a flow chart or text based description of the sequence of activities that must take place following the occurrence of an activating event.
- Control charts are used to (--13--) and (--14--).
- (--15--) and (--16--) are the most important properties of a good estimator.
- (--17--) and (--18--) are called producer's risk and consumer's risk, respectively.

Q (2:12): Two operators perform the same machining operation. Their supervisor wants to estimate the difference in the mean machining times between them. It can be assumed, however, that the distribution of machining times is normal for each operator. A random sample of 10 from the first operator gives an average machining time of 4 minutes with a standard deviation of 0.5 minutes. A random sample of 6 from the second operator yields an average machining time of 5 minutes with a standard deviation of 0.8 minutes. Use α=0.05,

a- Test the hypothesis that the two variances are qual. (4)

b- Find a 95% confidence interval for the difference in the mean machining times between the two operators. (3)

c- Test the hypothesis that the second operator's mean is larger than the first operator's mean by five. (4)

d- How much is the approximate p value? (1)

$\mu_2 \text{-} 5 > \mu_1$

$\mu_1 - \mu_2 < 5$

kAizen Team

Q (3:8) A company is interested in determining whether the proportions of nonconforming items are unequal for two of its vendors. A random sample of 100 items from the first vendor revealed 4 nonconforming items. A random sample of 200 items from the second vendor showed 10 nonconforming items. Use α of 0.05, what can you conclude? Construct a 90 % confidence interval on the difference between the two proportions.

Q (4:12): The time to process customer orders is known to be normally distributed. A random sample of 20 orders is selected. The average processing time is found to be 8 days with a standard deviation of 1.5. Use α of 0.1

a- Test the hypothesis that the standard deviation equals 2 versus the alternative hypothesis that the standard deviation is less than 2. (4)

b- Use the p-value to decide whether to reject or fail to reject the null hypothesis in part (a). (4)

c- Find a 90 % confidence interval for the variance of the order processing times. (4)

Q(5:9) Consider the Shewhart $\bar{x}$-control chart with 2-sigma limits. Assume the process in control,

a- Calculate the average run length (ARL) (3)

b- Is ARL an effective tool for sampling? Why or why not? (show calculations) (3)

c- If sampling is made every half an hour, calculate average time to signal (3)

Q(6:6) A quality characteristic of a product is normally distributed with mean 6 and standard deviation one. Specifications on the characteristic are $3 \le x \le 7$. A unit that falls within specifications on this quality characteristic results in a profit \$20. If $x < 3$, the profit is \$ -2, whereas if $x > 7$, the profit is \$ 4. Calculate the expected profit.

Q(7:6) Ferric chloride is used as a flux in some types of extraction metallurgy processes. Suppose that from long experience a reliable value for the standard deviation of flux container weight is determined to be 4 lb. How large a sample would be required to construct a 90 % two sided confidence interval on the mean that has a total width of 1 lb?

Q (8:6) It is estimated that the average number of surface defects in 20 m^2 of paper produced by a process is 4. What is the probability of finding no more than two defects in 40 m^2 of paper through random selection?

Q (9:6): The time to failure for a cathode ray tube can be modeled using a Weibull distribution with parameters $\beta = \frac{1}{3}$ and $\theta = 200$ hours. What is the probability of a tube operating for at most 800 hours?

Q(10:6) A lightbulb has a normally distributed light output with mean 5,000 end foot-candles and standard deviation of 50 end foot-candles. Find the lower specification limit such that only 0.5 % of the bulbs will not exceed the limit.

$P(Z < \frac{x-\mu}{\sigma}) = 0.5$

Q(11:6) Nonconformities occur in glass bottles according to a Poisson distribution. An inspector counts the surface-finish defects in dishwashers. A random sample of five dishwashers contain three such defects. Is there reason to conclude that the mean occurrence rate of surface-finish defects per dishwashers exceeds 0.5? Use $\alpha = 0.05$. Use the normal approximation to the poisson.

KAizen Team

الجامعة الأردنية
عمان

امتحان Mid الفصل الصيفي 20

اسم الطالب ______ رقمه الجامعي ______

المستوى سنة ثالثة الكلية الهندسة

القسم ______ المادة ______

التاريخ ______ العلامات

Q1	Q2-4	Q5-11
23	32	42

97/100

Q1: (1) Quality.

(2) Warning limit.

(3) 38

(4) Appraisal Costs.

(5) Histogram / (6) stem and leaf.

(7) Box Plot.

(8) Probability plotting.

(9) P-value.

(10) Statistical process Control.

(11) out of control process.

(12) Out-of-Control Action Plan

(13) improve the Process.

(14) use as estimating device and to determine capability of the Process

(15) point estimator should be unbiased, expected value of point estimator should be parameter between

(16) point estimator should have minimum variance. Any Point estimator is a random variable. minimum variance point estimator should have variance smaller than any other one

KAizen Team

Q2;

$n_1 = 10 \quad \bar{x}_1 = 4 , \quad S_1 = 0.5$

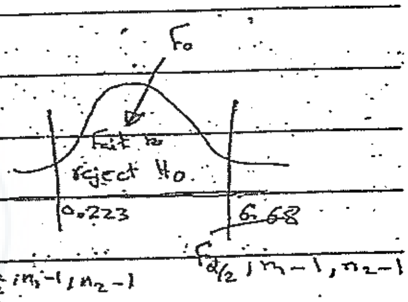
$n_2 = 6 \quad \bar{x}_2 = 5 , \quad S_2 = 0.8 \qquad ; \alpha = 0.05$

a) $H_0: \sigma_1^2 = \sigma_2^2$

$H_1: \sigma_1^2 \neq \sigma_2^2$

$$f_0 = \frac{s_1^2}{s_2^2} = \frac{(0.5)^2}{(0.8)^2} = 0.391$$

$$f_{0.025,9,5} = 6.68$$



$$f_{1-\frac{\alpha}{2}, n_1-1, n_2-1} = \frac{1}{f_{\frac{\alpha}{2}, n_2-1, n_1-1}}$$

$$= \frac{1}{f_{0.025,5,9}} = \frac{1}{4.48} = 0.223$$

$\Rightarrow$ Fail to reject $H_0 \Rightarrow \sigma_1^2 = \sigma_2^2$

b) $\alpha = 0.05$

Unknown σ^2 but equal.

$$S_p^2 = \frac{9(0.5)^2 + (5)(0.8)^2}{14} = 0.3893$$

$$S_p = 0.6239$$

$$\bar{x}_1 - \bar{x}_2 - t_{0.025,14} (S_p) \sqrt{\frac{1}{n_1} + \frac{1}{n_2}} \le \mu_1 - \mu_2 \le \bar{x}_1 - \bar{x}_2 + t_{0.025,14} \, S_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$$

$$4 - 5 - 2.145(0.6239)\sqrt{\frac{1}{10} + \frac{1}{6}} \le \mu_1 - \mu_2 \le 4 - 5 + 2.145(0.6239)\sqrt{\frac{1}{10} + \frac{1}{6}}$$

Kaizen Team

Q2

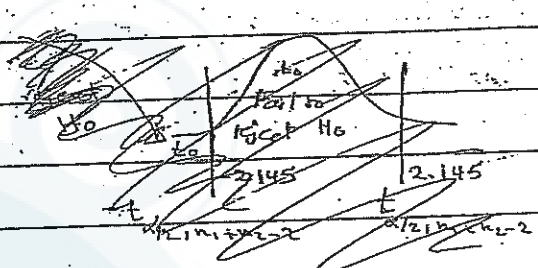
b) $-1.6911 < \mu_1 - \mu_2 < -0.3089$ 3

c) $H_0: \mu_1 - \mu_2 = 0$

$H_1: \mu_1 - \mu_2 < 5$ $(\mu_2 + 5 > \mu_1)$

$$t_0 = \frac{\bar{X}_1 - \bar{X}_2 - \Delta_0}{S_p\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}}$$

$$t_0 = \frac{4 - 5}{(0.6239)\sqrt{\frac{1}{10}+\frac{1}{6}}} = -6.011$$

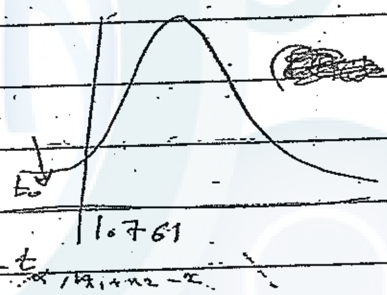


$t_{0.05,14} = 1.761$ 2

~~t = 2.145~~

$\Rightarrow$ reject H_0 $\Rightarrow$ the 2^{nd} mean is larger the the 1^{st} one by five.

d) [illegible] Not available in tables 1



KAizen Team..

Q3 $n_1 = 100$, $x_1 = 4$

$n_2 = 200$ $x_2 = 10$, $\alpha = 0.05$

* $\hat{p}_1 = \frac{x_1}{n_1} = \frac{4}{100} = 0.04$

* $\hat{p}_2 = \frac{x_2}{n_2} = \frac{10}{200} = 0.05$

$H_0: P_1 = P_2$

$H_1: P_1 \neq P_2$

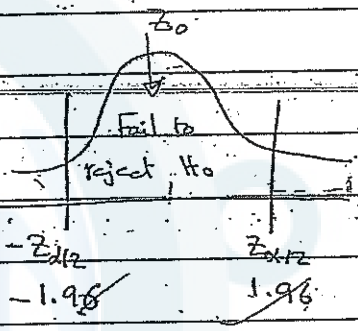
$$Z_0 = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{\hat{p}(1-\hat{p})\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}}$$

$$\hat{p} = \frac{x_1 + x_2}{n_1 + n_2} = \frac{4+10}{100+200} = 0.0467$$

$$= \frac{0.04 - 0.05}{\sqrt{0.0467(0.9533)\left(\frac{1}{100}+\frac{1}{200}\right)}}$$

$= 0.0006678$

6



$Z_{0.025} = 1.96$

$\Rightarrow$ Fail to reject H_0

(they are equal)

$\alpha = 0.1$

$$\hat{p}_1 - \hat{p}_2 - Z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}} \le P_1 - P_2 \le \hat{p}_1 - \hat{p}_2 + Z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

$$0.04 - 0.05 - 1.64\sqrt{0.000384 + 2.37\times10^{-4}} \le P_1 - P_2 \le 0.04 - 0.05 + 1.64\sqrt{6.215\times10^{-4}}$$

$$-0.011 \le P_1 - P_2 \le 0.031$$

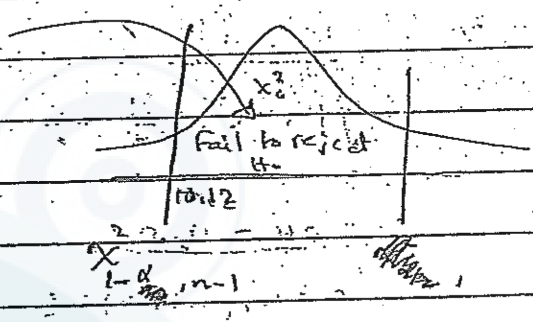
KAizen Team ..

Q.4. $n = 20$, $\bar{x} = 8$, $s = 1.5$, $\alpha = 0.05$

a) $H_0: \sigma^2 = 4$

$H_1: \sigma^2 < 4$ (one sided)

$$\chi^2_0 = \frac{19(1.5)^2}{4} = 10.688$$



$\chi^2_{0.95,19} = 10.12$ 4

$\Rightarrow$ fail to reject H_0

b) $\chi^2_0 = 10.688$

0.95 0.5

10.12 10.68 18.34

P-value ≈ 0.82?

4

$\Rightarrow \alpha <$ P-value $\Rightarrow$ fail to reject H_0.

c) $\alpha = 0.1$

$$\frac{(n-1)s^2}{\chi^2_{\alpha/2, n-1}} < \sigma^2 < \frac{(n-1)s^2}{\chi^2_{1-\frac{\alpha}{2}, n-1}}$$

4

$$\frac{19(1.5^2)}{\chi^2_{0.05,19}} < \sigma^2 < \frac{19(1.5^2)}{\chi^2_{0.95,19}}$$

30.14 10.12

Kaizen Team

Q4

c) $0.1018 \le \sigma^2 \le 4.224$

Q5:

a) $ARL = \frac{1}{p} = \frac{1}{0.00455} = 219.78$

3

b) No it is not effective, because the standard deviation usually is approximately equal to the mean.

c) $ATS = ARL \cdot h$

$ATS = 219.78\left(\frac{1}{2}\right) = 109.89$ hours

Q6: $\mu = 6$, $\sigma = 1$

$P(3 \le x \le 7)$

$= P(x \le 7) - P(x \le 3)$

$= P\left(Z \le \frac{7-6}{1}\right) - P\left(Z \le \frac{3-6}{1}\right)$

3

$= P(Z \le 1) - P(Z \le -3)$

$= 0.84134 - 0.0014$

$= 0.83994$

21

KAizen Team G

الجامعة الأردنية
عمـان

اسم الطالب [redacted] رقمه الجامعي 0076475

المستـــوى ________ الكليـــــة ________

القســـم ________ المـــادة ________

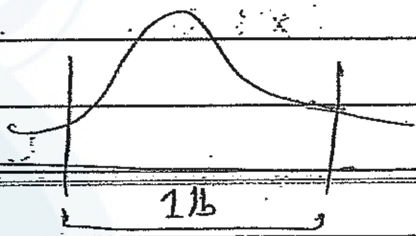
التاريـــخ ________ [redacted]

العلامـــــــات

Q.7:

$\sigma = 4$, $n = ?$, $\alpha = 0.1$

$$Z_{\alpha/2} \cdot \frac{\sigma}{\sqrt{n}} = \frac{1}{2}$$



$$\left(Z_{0.05} \cdot \frac{4}{\sqrt{n}}\right) = \frac{1}{2}$$

$$1.64 * \frac{4}{\sqrt{n}} = \frac{1}{2}$$

6

$$6.56 = \frac{\sqrt{n}}{2} \Rightarrow \sqrt{n} = 13.12$$

$$\Rightarrow n = 172.13$$

KAIZEN Team

Q.8 : 4 defect / 20 m^2 ; ? 140 m^2 } $\lambda = \frac{4 \times 40}{20} = 8$ defects

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

$= \frac{e^{-8}(8)^2}{2!} + \frac{e^{-8}\,8^1}{1!} + \frac{e^{-8}(8)^0}{0!}$

$= 0.011 + 0.00268 + 3.35 \times 10^{-4}$

$= 0.014$

9

Q.9 : $\beta = \frac{1}{3}$, $\theta = 200$

$P(X \le 800) = 1 - \exp\left[-\left(\frac{800}{\theta_{=200}}\right)^{\beta}\right]$

$= 1 - \exp\left[-(4)^{1/3}\right]$

$= 0.7955$

6

Q.10 : $\mu = 5000$, $\sigma = 50$

$P(X \le LSL) = 0.005$

$P\left(Z \le \frac{LSL - \mu}{\sigma}\right) = 0.005$

$P\left(Z \le \frac{LSL - 5000}{50}\right) = 0.005$

$P(Z \le 2.57) \Rightarrow \frac{LSL - 5000}{50} = 2.57$

$LSL = 5128.5$

4

KAIZEN Team

Q 11 , $n = 5$, $D = 3$,

$$\mu_{\bar{x}} = \lambda = 0.5$$

$$\sigma_{\bar{x}}^2 = \frac{\lambda}{n} = \frac{0.5}{5} = 0.1$$

1

KAIzen Team

University of Jordan

Department of Industrial Engineering

QUALITY CONTROL (12/7/09)

DR. Al-Refaie, A.

14

Student name: Alaá Khalil **SR#:** 20

0076922

Q(1-3) Please answer the following questions concisely:

What is the traditional definition of quality? Provide an example for each type of critical-to-quality characteristics.

Quality means fitness for use

1) physical: weight

2) sensory: taste

3) time orientation: reliability.

What is the difference between nonconforming product and defective product?

2

none conforming: that fail to meet one or more of it's specifications, it is not necessarily unfit for use.

defective product: if it has one or more defect which are ~~nonconforming~~ nonconformities that are serious enough to significantly affect the safe of use

contain one or more seriuse nonconforming (function)

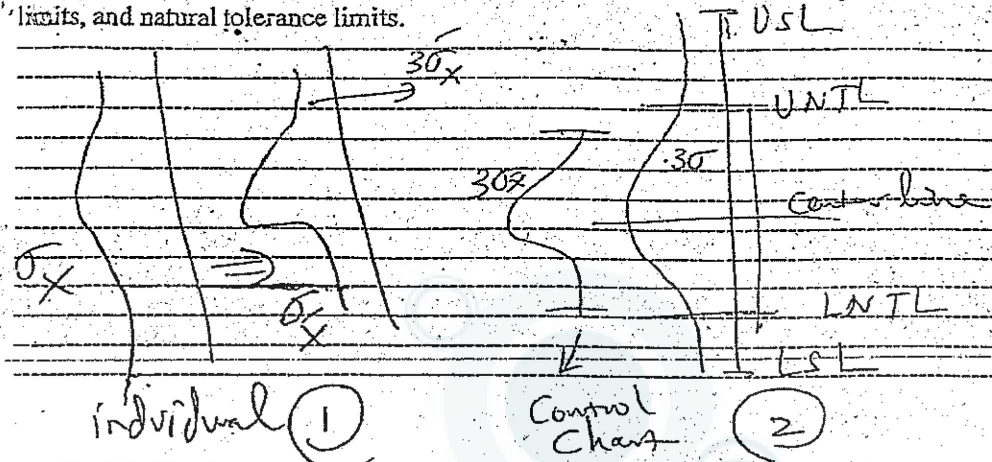
Draw the phase diagram for the use of quality-engineering methods.

don't effect variability.

smaller variability.

Q2(4). Illustrate how the control charts works. Illustrate the relationship between control limits, specification limits, and natural tolerance limits.

P 238



Q3(6). Samples of fabric from a textile mill, each of 100 m^2, are selected, and the number of occurrences of foreign matter are recorded. Data for 25 samples shows a total number of nonconformities of 180.

a:2 What is the proper control chart to be used for monitoring future production? Calculate the 3 sigma control limits for this chart.

$c = \frac{180}{25} = 7.2$ $UCL = 15.25 \rightarrow \bar{c} + 3\sqrt{\bar{c}}$

$CL = 7.2$ $\bar{c}$

$LCL = zero$

Procedures with constant sample size

P 309

b:2 Suppose a sample of 16 nonconformities is found out of control with assignable cause? What will be the effect on the control chart in part a?

$\bar{c} = \frac{(180-16)}{24} = 6.83$ $UCL = 14.673$

$LCL = zero$

c:2 Suppose the nonconformities are observed in 50 m^2, calculate 2 sigma control limits for the revised limits and centerline for the revised control chart.

$n = 1/2$ $n\bar{c} = 1/2 (7.2) = 3.6$

$n\bar{c} + 2\sqrt{n\bar{c}} = 7.4$

$n\bar{c} - 2\sqrt{n\bar{c}} = 0$

Total nonconformities = 180

$n = 100$

$m = 25$

$\bar{c} = \frac{180}{25} = 7.2$

15.2

$\frac{180-16}{24}$

$n\bar{c}$

P in 1st or 2nd

$\alpha \rightarrow$ type I error

Detect = $1-B$ — $P(1-B) + P(B(1-B))$

not Detect = B

B $\mu = 610$ $B = \frac{LCL - \mu_{new}}{4/\sqrt{n}}$

b(4) What is the probability of detecting a shift in the process mean to 610 at the first or second subsequent sample following the shift? Assume σ remains constant. $\frac{\bar{R}}{d_2} = 4$ $P(1-B) + P(B(1-B))$

$(1-\beta) = p(\bar{x} < LCL) + p(\bar{x} > UCL)$ $\beta = 0.0222$

$= \phi\left(\frac{LCL - \mu_{new}}{4/\sqrt{4}}\right) + 1 - \phi\left(\frac{UCL - \mu_{new}}{4/\sqrt{4}}\right)$ $\beta = 0.0222$

$= \phi\left(\frac{640 - 610}{4/\sqrt{4}}\right) + 1 - \phi\left(\frac{614 - 610}{4/\sqrt{4}}\right)$ 0.99772 50 $\Rightarrow$ ~~0.9995~~

$\beta = (1 - \text{Prob. det})$ $\Rightarrow$ Prob. det $+ (1 - \text{Prob. det}) \cdot (\text{Prob. det})$

$P(1-B) + P(B(1-B))$

2- For $\bar{x}$-s charts (8): (5.52) α $0.97725 + (0.0222)(0.97725) = 0.9995$

a(3) For $\bar{x}$ chart, find the probability of type I error, assuming σ is constant.

$\alpha = Pr(\bar{x} < LCL) + p(\bar{x} > UCL)$ $\sigma_x = \bar{s}/c_4 = 8/0.9213 = 8.68$

$= \phi\left(\frac{LCL - 700}{\sigma/\sqrt{4}}\right) + 1 - \phi\left(\frac{UCL - \bar{x}}{\sigma/\sqrt{4}}\right)$ ~~α~~ type 2 β

$= \phi\left(\frac{690 - 700}{\sigma/\sqrt{4}}\right) + 1 - \phi\left(\frac{710 - 700}{\sigma/\sqrt{4}}\right)$ type 1 α

$= \phi(-2.3) + 1 - \phi(2.3) = 2(1 - 0.98928)$

$\mu = 693$ $\sigma = 12$ $= 0.0214$

b(5) Suppose the process mean shifts to 693 and the standard deviation shifts to 12. Find the average run length and average time to signal if samples are taken at equally spaced intervals of 0.5 hour. h

$\alpha = Pr(\bar{x} < LCL) + p(\bar{x} > UCL)$

$\frac{LCL - \mu}{\sigma/\sqrt{n}}$

$= \phi\left(\frac{690 - 693}{12/\sqrt{4}}\right) + 1 - \phi\left(\frac{710 - 693}{12/\sqrt{4}}\right)$

$= \phi(-0.5) + 1 - \phi(2.83) = 0.3085 + 1 - 0.9977$

$= 0.3108$

$ARL = \frac{1}{0.3108} = 3.06$

$ATS = 3.06 \times 0.5 = 1.53\ hr$

chap

$m = 16$, $n = 4$

c, $u \to nc$

Q6.(6) An automobile manufacturer wishes to control the number of nonconformities is a subassembly area producing manual transmissions. The inspection unit is defined as four transmissions. The following 16 samples are collected (each of size 4).

u-chart

m $M = 16$ n

6-44(c)

$CL = \bar{u} = \sum u_i / m = (\sum x_i / n) / m$

$= (27/4)/16 = 0.422$

$UCL = \bar{u} + 3\sqrt{\bar{u}/n}$

$LCL = \bar{u} - 3\sqrt{\bar{u}/n}$

#	No. of nonconformities	#	No. of nonconformities
1	1	9	2
2	3	10	1
3	2	11	0
4	1	12	2
5	0	13	1
6	2	14	1
7	1	15	2
8	5	16	3

m

a(3)- Suppose the inspection unit is redefined as eight transmissions, design control chart for average number of nonconformities per unit. u-Chart

The new sample is $n = 8/4 = 2$

$n = \frac{new}{old}$

Since this chart was established for average nonconformities per unit, the same control limits may be used.

$n = 2$ مش مهم

$UCL = 0.698$

$CL = 0.21$

$LCL = 0$

b(3)- If the inspection unit is redefined as two transmissions, construct nc-chart.

$\bar{c} = \frac{\sum N_{c}(b)}{m}$ $2/4 = 0.5$ $\bar{c} = 1.6878$

$n = 1/2 \Rightarrow n\bar{c} = 0.843$

$UCL = \bar{c} + 3\sqrt{\bar{c}}$ $n\bar{c} + 3\sqrt{n\bar{c}} = 3.6$

$LCL = \bar{c} - 3\sqrt{\bar{c}}$ $n\bar{c} - 3\sqrt{n\bar{c}} = 0$

Q7. (16) Given the following (assume normally distributed quality characteristic):

(1) The $\bar{x}$ - R charts:

- The $\bar{x}$ chart: μCL = 626 UCL = 640 LCL = 614 $n = 4$ specifications: 610±15
- The R chart: UCL = 18.8 CL = 8.2 LCL = 0

(2) The $\bar{x}$ -s charts:

- The $\bar{x}$ chart: UCL = 710 CL = 700 LCL = 690 $n = 4$ specifications: 705±15
- The s chart: UCL = 18 $\bar{S}$ CL = 8 LCL = 0

1- For $\bar{x}$ - R charts (8): (5:50)   Specification limits $P(\bar{x} > USL)$, P

a(4) What would be the estimate of the fraction nonconforming and process capability index?

$\hat{\sigma} = \bar{R}/d_2 = 8.2/2.059 \cong 4$

① $\hat{p} = Pr(x < LSL) + P(x > USL)$

$\left(\frac{LSL - \mu}{\hat{\sigma}}\right)$ $= \Phi\left(\frac{595 - 626}{4}\right) + 1 - \Phi\left(\frac{625 - 626}{4}\right)$ $\left(\frac{USL - \mu}{\hat{\sigma}}\right)$

$0 + 1 - 0.00621$

$= \Phi(-7.75) + 1 - \Phi(-0.25)$ ≈ 0.40129

② $C_p = \frac{USL - LSL}{6\hat{\sigma}} = \frac{625 - 595}{6 \times 4} = 1.2553$

$\hat{\sigma} \to \bar{R}/d_2$

(KAizen-Team)

Answer sheet

UNIVERSITY OF JORDAN
Dept. of Industrial Engineering
Quality Control (Final Exam 4/6/09)
INSTRUCTOR: DR. AL-REFAIE, A.

NAME: .... ID: .... SR #: ......

FINAL ANSWERS SHOULD BE PROVIDED WITH DETAILED CALCULATIONS

Q1.(12) Please fill in the blank the missing terms or phrases in the below table:

- The control chart detects only (1) causes. assignable
- The (2) chart is simply a frequency distribution of attribute data arranged by category. Pareto chart
- The (3) is a formal tool frequently useful in underlying potential causes. cause & effect diag.
- The (4) is a useful plot for identifying a potential relationship between two variables. scatter diag
- (5) is simply the percentage of the specification band that the process uses up. $(1/C_p)\times 100\%$
- The (6) is used when the sample size n is moderately large; *i.e.*, 10 or greater. $\bar{x}$-S charts
- The (7) is the number of time periods that occur until a signal is generated on the control chart. ATS
- The (8) is used when repeat measurement on the process differ only because of analysis error. Individ...
- (9) is indicated when the plotted points tend to fall near or slightly outside the control limits. mixture
- The (10) is defined as the ratio of the number of nonconforming items in a population to the total number of items in that population. fraction non conforming
- If the process in out of control and capable, then the action taken to improve a process will be (11). SPC
- The (12) chart is used to control nonconformities on a product with variable inspection units. u-chart

1	assignable	7	ATS
2	Pareto chart	8	Individual - Moving range
3	cause & effect	9	mixture
4	Scatter diag.	10	fraction noncomf.
5	$1/C_p \times 100\%$	11	SPC
6	$\bar{x}$-S chart	12	u-chart

Q2.(2) A manufacturer used the p chart with CL= 0.1, UCL = 0.19, and LCL= 0.01 to control a process. If the 2-sigma limits are used, find the sample size for this chart. (6-18a)

$UCL = p + 2\sqrt{p(1-p)/n}$

$\Rightarrow n = p(1-p)\left(\frac{2}{UCL - p}\right)^2 \Longrightarrow n = 45$

1

Kaizen Team

Q3(3) In designing a fraction nonconforming chart with center line at p = 0.2 and two-sigma control limits. (a) what is the sample size required to yield a positive lower control limit? (b) What is the value of n necessary to give a probability of 0.5 of detecting a shift in the process to 0.26? (6-14)

(1) $p = 0.2$ $L = 2$

$n > \frac{(1-p)}{p} L^2$ $n > 16$

(2) $p_{new} = 0.26$ $\delta = 0.26 - 0.2 = 0.06$

$n = \left(\frac{k}{\delta}\right)^2 p(1-p) = \left(\frac{2}{0.06}\right)^2 (0.2)(1-0.2)$

$= 178$

Q4(3) Surface-finish defects in a small electric appliance occur at random with a mean rate of 0.1 defects per unit. Find the probability that a randomly selected unit will contain at most two surface-finish defects.

(2-38)

$p(x \leq 2) = 1 - p_r(x \leq 1)$

$= 1 - [p(x=0) + p(x=1)] = 1 - \left[\frac{e^{-0.1}(0.1)^0}{0!} + \frac{e^{-0.1}(0.1)^1}{1!}\right] = 0.995$

Q5.(8) Two different hardening processes A and B are used on samples of a particular alloy. Assume the hardness is normally distributed. Given that $\alpha = 0.05$ and

$\bar{x}_A = 147$ $s_A = 5.0$ $n_A = 10$

$\bar{x}_B = 149$ $s_B = 5.5$ $n_B = 10$

a(3) Test the hypothesis that the two variances are equal.

$H_0: \sigma_1^2 = \sigma_2^2$

$H_1: \sigma_1^2 \neq \sigma_2^2$

$F_0 = \frac{S_1^2}{S_2^2} = 0.826$

$F_{\alpha/2}$ $1 - F_{\alpha/2, n_1-1, n_2-1}$ F $F_{\alpha/2, n_1-1, n_2-1}$

0.248 4.03

Fail to reject

b(3) Test the hypothesis that the mean hardness for process A is greater than the mean hardness for process B (assume equal variances).

$H_0: \mu_1 = \mu_2$

$H_1: \mu_1 > \mu_2$

$S_p^2 = \frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1+n_2-2}$ $S_p = 5.26$

$t_0 = \frac{\bar{x}_1 - \bar{x}_2}{S_p\sqrt{1/n_1 + 1/n_2}}$ $t_0 = -0.807$

$t_{\alpha, n_1+n_2-2} = 1.734$

18

c(2)- Construct a 95 % confidence on the variance of process A.

$\frac{(n-1)s^2}{\chi^2_{\alpha/2, n-1}} \leq \sigma^2 \leq \frac{(n-1)s^2}{\chi^2_{1-\alpha/2, n-1}}$

$\frac{9(5^2)}{19.02} \leq \sigma^2 \leq \frac{9.5^2}{2.7}$ 2/4

$11.829 \leq \sigma^2 \leq 83.333$

KAizen Team

Q6.(6) An automobile manufacturer wishes to control the number of nonconformities is a subassembly area producing manual transmissions. The inspection unit is defined as four transmissions. The following 16 samples are collected (each of size 4).

$CL = \bar{u} = \sum u_i/m = \overset{6.44(c)}{(\sum x_i/n)}/m = (27/4)/16 = 0.422$

$UCL = \bar{u} + 3\sqrt{\bar{u}/n}$

$LCL = \bar{u} - 3\sqrt{\bar{u}/n}$

#	No. of nonconformities	#	No. of nonconformities
1	1	9	2
2	3	10	1
3	2	11	0
4	1	12	2
5	0	13	1
6	2	14	1
7	1	15	2
8	5	16	3

a(3)- Suppose the inspection unit is redefined as eight transmissions, design control chart for average number of nonconformities per unit.

The new sample is $n = 8/4 = 2$ inspection unit

Since this chart was established for average nonconformities per unit, the same control limits may be used.

sample size of 2 transmission unit $\bar{u} = \left(\frac{27}{2 \times 16}\right)$ ⇐ $UCL = 0.848$, $CL = 0.21$, $LCL = 0$

b(3)- If the inspection unit is redefined as two transmissions, construct nc-chart.

$\bar{c} = 27/16$ $\bar{c} = 1.6818$

$UCL = \bar{c} + 3\sqrt{\bar{c}}$, $n = 1/2 \Rightarrow n\bar{c} = 0.843$

$LCL = \bar{c} - 3\sqrt{\bar{c}}$, $n\bar{c} + 3\sqrt{n\bar{c}} = 3.6$

$n\bar{c} - 3\sqrt{n\bar{c}} = 0$

sample size of 2 transmission = 1/2 inspection unit

Q7. (16) Given the following (assume normally distributed quality characteristic):

(1) The $\bar{x}$ - R charts:

- The $\bar{x}$ chart: UCL = 626 CL = $\overset{640}{620}$ LCL = 614 $n = 4$ specifications: 610±15
- The R chart: UCL = 18.8 CL = 8.2 LCL = 0

(2) The $\bar{x}$ -s charts:

- The $\bar{x}$ chart: UCL = 710 CL = 700 LCL = 690 $n = 4$ specifications: 705±15
- The s chart: UCL = 18 CL = 8 LCL = 0

1- For $\bar{x}$ - R charts (8): (5:50)

a(4) What would be the estimate of the fraction nonconforming and process capability index?

$\hat{\sigma} = \bar{R}/d_2 = 8.2/2.059 \cong 4$

① $\hat{p} = Pr(x < LSL) + P(x > USL)$

$= \Phi\left(\frac{595 - 626}{4}\right) + 1 - \Phi\left(\frac{625 - 626}{4}\right)$

$= \Phi(-7.75) + 1 - \Phi(-0.25) \cong 0.40129$

② $C_p = \frac{USL - LSL}{6\hat{\sigma}} = \frac{625 - 595}{6 \times 4} = 1.25$

3

10.5

7
8
7
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10
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8
63

Industrial Engineering Department
Quality Control - 96352
exam # 1

شعبة (٢) (ث، ن)

Saturday 29/3/2003
60 minutes

Name: علاء محمود سرحان
Number: 0005557

Question 1: (fill in the spaces) (10 points)

7/10

1. Quality improvement is achieved through the reduction of variability in processes and products.
2. The sample average is a measure of central tendency.
3. The standard deviation is a measure of scatter, spread or variability.
4. The probability distribution of a random variable representing the number of defective units in a sample is binomial.
5. The probability distribution of a random variable representing the number of required samples until the third out of control sample point is detected is negative binomial (Pascal)
6. In acceptance sampling, the distribution of a random variable representing the number of defective units in a sample drawn from a lot of known size and percent defective is hypergeometric.
7. The probability that a point plots outside the control limits immediately after a shift in the process mean occurs is equal to $1-\beta$. −1
8. The statistic that is plotted on a $\bar{X}$-chart is ~~CL~~ $CL = \mu_{\bar{x}} = \bar{\bar{x}}$
9. The R-chart is used to monitor variability ~~variance~~ a sample. −1
10. The $\bar{X}$-chart is used to monitor variability ~~mean~~ samples. −1

(μ) mean change → $\bar{X}$-chart
(σ^2) 6 change → R-chart

Question 2: (true / false) (10 points)

8/10

1. $\phi(2) < 1-\phi(-2)$ x → $\phi(2) = 1-\phi(-2)$
2. $\phi(3) > \phi(1)$ ✓
3. $\phi(1) + \phi(-1) = 1.00$ ✓
4. Type-I error is committed when one says that the process is out of control when it is actually in control. x
5. Type-II error is the probability that a point plots outside the control limits. x
6. The relationship $\alpha=1-\beta$ is only true when the process is in control. ✓ no shift occurs ($k=0$)
7. Quality improvement is achieved through the production of products with best quality. x
8. The power of the chart is the probability that a point plots outside the control limits immediately after a shift in the process mean occurs. ✓ $(1-\beta)$
9. ARL is the average number of samples required until a point plots outside the control limits by chance. x
10. Control charts, design of experiments and acceptance sampling are all part of the statistical methods for quality improvement. ✓

Question 3: (multiple choice questions) (10 points)

7/10

1. A cause and effect diagram is used for:
   a. Checking randomness of data.
   b. Checking distribution of data.
   c. Determining reasons for possible problems.
   d. Determining the flow of a process.
2. Which of the following statements is true?
   a. Type-II error is the probability that a point plots inside the control limits.
   b. The relationship $\alpha=1-\beta$ is always true.
   c. Type-I error is the probability that a point plots outside the control limits.
   d. All of the above.
3. The power of the chart is:
   a. the probability of making type-II error.
   b. the probability that a point plots outside the control limits immediately after a shift in the process mean occurs.
   c. the average number of samples required to detect a shift in the process mean.
   d. The ability of a chart to detect out of control conditions.
4. A value of a measurement that corresponds to the desired value for a quality characteristic is called:
   a. lower specification limit
   b. nominal value
   c. upper specification limit
   d. process mean

5. A histogram is used for:
   a. Checking randomness of data.
   b. Checking the distribution of data.
   c. Checking trends in data.
   d. None of the above.
6. Which of the following is not part of the statistical methods for quality improvement?
   a. control charts
   b. design of experiments
   c. total quality management
   d. acceptance sampling
7. Which of the following a control chart does not do?
   a. process correction
   b. process monitoring
   c. detection of possible problems
   d. detection of non-random process behavior
8. The performance dimension of quality answers the following question:
   a. what does the product do?
   b. will the product do the intended job?
   c. is the product made exactly as the designer intended?
   d. how long does the product last?
9. The reliability dimension of quality answers the following question:
   a. When does the product fail?
   b. How often does the product fail?
   c. How long does the product last?
   d. How easy is it to repair the product?
10. Which of the following statements is true?
   a. Quality is directly proportional to variability.
   b. Quality is inversely proportional to variability.
   c. Quality means fitness for use.
   d. (b) and (c).

9 -

Question 4: (10 points)

i. A production process operates with 2% nonconforming output. Every hour a sample of 10 units is taken. If 1 or more nonconforming units are found, the process is stopped. What is the probability that the process will not be stopped on the next sample?

X ~ Binomial (n=10, p=...

$P(x=0) = \binom{10}{0}(.02)^0(.98)^{10} = (.98)^{10}$

9/10

ii. What is the probability that at most 10% of the sample will be nonconforming?

$\boxed{\hat{p} = \frac{x}{n}}$

$P(\frac{x}{n} \le .1) = P(x \le 1) = P(x=0) + P(x=1) = (.98)^{10} + \binom{10}{1}(.02)(.98)^9$

$= (.98)^{10} + (.2)(.98)^9$

$= (.98)^9(.98 + .2) = (.98)^9($

Question 5: (10 points)

i. A lot of size N=10 contains 3 nonconforming units. What is the probability that a sample of 3 units selected at random contains exactly one nonconforming unit?

Hypergeometric distribution

$\binom{3}{1} \binom{7}{2}$

$\binom{10}{3}$

$\binom{N}{n}$

10/10

$\boxed{P(1) = \frac{21}{210}} = \frac{3 \times 21}{4 \cdot 12 \cdot \times 10}$

$\sigma = \sqrt{16} = 4$

ii. If $X \sim N(\mu, \sigma^2 = 16)$. What is the value of μ if the probability that X is less than 32 is equal to 0.5?

$P(X < 32) = .5$

$P\left(Z < \frac{32 - \mu}{\sigma}\right) \quad P\left(Z < \frac{32 - \mu}{4}\right) = .5$

$Z = 0 \longrightarrow \frac{32-\mu}{4} = 0 \quad \boxed{\mu = 32}$

Question 6: (15 points)

The in-control model for a certain quality characteristic ($\bar{X}$) is given by CL = 10, UCL = 13.09 and LCL = 6.91 with 0.001 probability limits and n = 4.

$UCL = CL + 3.09\sigma$

$LCL = CL + -3.09\sigma$

i. Estimate the process parameters μ and σ.

$\mu_{\bar{x}} = CL = \mu_{process} = \bar{\bar{x}} = 10$

$\sigma_{\bar{x}} = \frac{\sigma_{process}}{\sqrt{n}}$

$UCL = 13.09 = 10 + 3.09\sigma$

$\sigma_{\bar{x}} = \sigma = 1 = \frac{\sigma_P}{\sqrt{4}}$

$\sigma = \sigma_{\bar{x}}$

$13.09 - 10 = 3.09\sigma \longrightarrow 3.09 = 3.09\sigma \longrightarrow \boxed{\sigma = 1} \quad \boxed{\sigma_P = 2}$

8/15

ii. What is the probability that a shift in mean to $\mu_{new} = 13.09$ will be detected immediately on the first sample following the shift?

$\mu_{new} = \mu_{old} + k\sigma_{process} = 10 + k\sigma_P = 13.09 \longrightarrow 10 + k(2) = 13.09$

$2k = 3.09$

$k = \frac{3.09}{2}$

$\beta = \Phi(3.09 - k\sqrt{n}) - \Phi(-3.09 - k\sqrt{n})$

$\beta = \Phi\left(3.09 - \frac{3.09}{2}\sqrt{4}\right) - \Phi\left(-3.09 - \frac{3.09}{2}\sqrt{4}\right)$

iii. What is the average run length for this chart?

$ARL = \frac{1}{1-\beta} = \frac{1}{1-\Phi(0)}$ —5

$\beta = \Phi(0) - \Phi(-6.18) = \Phi(0) = ?$ —2

$1 - \beta$ = probability that a shift of mean will be detected immediately

Question 7: (15 points)

An $\bar{X}$-chart with 0.001 probability limits has been constructed to monitor a certain quality characteristic. The following two rules are used to determine if the process is out of control:

$Z = \frac{X - \mu}{\sigma}$

1. If one sample point plots outside the control limits.
2. If three consecutive sample points plot above the median.

i. What is α_1 associated with rule (1)? $\alpha = P(X > UCL) + P(X < LCL) = P\left(Z > \frac{\bar{\bar{x}} + 3.09\sigma - \bar{\bar{x}}}{\sigma}\right)$

$.001 * 2$

$.002$

$+ P\left(Z < \frac{\bar{\bar{x}} - 3.09\sigma - \bar{\bar{x}}}{\sigma}\right) = P(Z > 3.09) + P(Z < -3.09)$

$[1 - \Phi(3.09)] + \Phi(-3.09) = 2\Phi(-3.09) = \alpha_1$ —5

$2(.001)$

ii. What is α_2 associated with rule (2)?

$\alpha_2 = (.5)^3 = ?$ —1

6/15

iii. Show that α-total associated with both rules is given by $1-(1-\alpha_1)(1-\alpha_2)$.

Probability to $(1-\alpha_1)$ that the point in control limit (first rule)

to $(1-\alpha_2)$ (second rule)

?

that is in control [illegible] $1-(1-\alpha_1)$ [illegible] —3

[illegible] are independent

Question 8: (10 points)
Consider the following data for a certain quality characteristic:
$\Sigma \bar{X}_I = 500$, $\Sigma R_I = 50$, m=25, n=4, $d_2 = 2$, $d_3 = 0.9$.
Construct appropriate $\bar{X}$ and R charts. with 3σ limits.

$\bar{X}$-chart

$CL = \mu_{\bar{x}} = \bar{\bar{x}} = \frac{\Sigma \bar{x}}{25} = \frac{500}{25} = 20$ ✓

$UCL = CL + 3\sigma_{\bar{x}} = 20 + 3(\frac{1}{2}) = 23.5$ ✗

$LCL = CL - 3\sigma_{\bar{x}} = 20 - 3(\frac{1}{2}) = 20 - 3.5$
$= 16.5$

-2

8/10

$\bar{R}$-chart

$CL = \bar{R} = \mu_R = \frac{\Sigma R}{25} = \frac{50}{25} = 2$

$UCL = CL + 3\sigma_R = 2 + 3(.9) = 2 + 2.7 = 4.7$

$LCL = CL - 3\sigma_R = 2 - 3(.9) = 2 - 2.7$
$= -.7$ it will be = zero ✓

σ process

$\sigma_{\bar{x}} = \frac{\sigma_x}{\sqrt{n}} = \frac{\sigma_x}{\sqrt{4}} = \frac{\sigma_x}{2}$

$\sigma_x = \frac{\bar{R}}{d_2} =$

$\bar{R} = \frac{\Sigma R}{25} = \frac{50}{25} = 2$

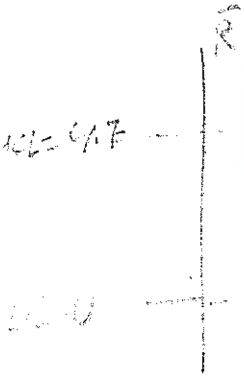
$d_2 = 2$, $d_3 = .9$

$\sigma_p = \sigma_x = \frac{\bar{R}}{d_2} = \frac{2}{2} = 1$

$\sigma_{\bar{x}} = \frac{\sigma_x}{2} = \frac{1}{2}$

$\sigma_R = d_3 \sigma_{process}$

$\sigma_R = (.9)(1) = .9$



24
18
20
15
20
97/100

Industrial Engineering Department
Quality Control - 96352
exam # 1

Saturday 25/3/2000
60 minutes

Name: Rana Saleh

Number: 984915

(9-10)

Question 1: (25 points)

I. **Fill in the spaces:**

1. Quality improvement is achieved through the reduction of variability in processes and products.
2. A value of a measurement corresponding to the desired value of a quality characteristic is called ~~conformancy~~. nominal or target value
3. The largest and smallest allowable values for a quality characteristic are called specification limits
4. The sample average is a measure of central tendency
5. The standard deviation is a measure of scatter. spread
6. The probability distribution of a random variable representing the number of defective units in a sample is binomial.
7. The probability distribution of a random variable representing the number of required samples until the third out of control sample point is detected is Pascal (Negative binomial)
8. The probability distribution of a random variable representing the number of defects in a square meter of carpet is Poisson distribution
9. In acceptance sampling, the distribution of a random variable representing the number of defective units in a sample drawn from a lot of known size and percent defective is (hyper geometric)
10. The relationship $\alpha=1-\beta$ is only true when process is in control actually ← no shift in mean or standard deviation
11. The probability that a point plots outside the control limits immediately after a shift in the process mean occurs is $1-\beta$.

14/25

II. **True / False:**

-3 3

1. $\phi(3) = 1-\phi(-3)$ ✓
2. $\phi(3) < \phi(2)$ X
3. $\phi(3) + \phi(-3) = 0.0027$ X = 1
4. Type-II error is the probability that a point plots inside the control limits. X / process is out of control
5. The relationship $\alpha=1-\beta$ is always true. X
6. Type-I error is the probability that a point plots outside the control limits. ✓
7. Quality improvement is achieved through the production of products with best quality. X
8. The power of the chart is the ability of a control chart to detect out of control conditions ✓
9. ARL is the average number of samples required to detect a shift in the process mean. ✓
10. ATS is the average time until a shift in process mean is detected. ✓
11. Control charts, design of experiments and acceptance sampling are all part of the statistical methods for quality improvement. ✓
12. Control charts are designed for the purpose of process correction. X
13. The performance dimension of quality answers the question "will the product do the intended job?" ✓

-1

Question 2: (20 points) $P = 0.02$

i. A production process operates with 2% nonconforming output. Every hour a sample of 10 units is taken. If 1 or more nonconforming units are found, the process is stopped. What is the probability that the process will not be stopped on the next sample?

X : # of non conforming parts in sample(n=10) $X \sim$ binomial $(\overset{p}{0.02}, \overset{n}{10})$

process not be stopped mean $p(X=0)$

$p(X=0) = (0.98)^{10}$ ✓

ii. For the same process in part (a), what is the probability that the fraction nonconforming of the next sample is less than 0.1?

$\cancel{\hat{p} = \frac{X}{n} \Rightarrow X = 1}$

$\beta = p(\frac{X}{n} < 0.1) = p(X < 1) = p(X=0) = (0.98)^{10}$

iii. A lot of size N=10 contains 3 nonconforming units. What is the probability that a sample of 3 units selected at random contains exactly one nonconforming unit?

X : # of non conforming units in sample of size 3 ← $\frac{3}{10}$

$p(X=1) = \frac{\binom{3}{1}\binom{7}{2}}{\binom{10}{3}} = ?$ −2

18/20

iv. If $X \sim N(\mu, \sigma^2 = 16)$. What is the value of μ if the probability that X is less than 32 equals 0.5?

$p(X < 32) = 0.5$

$p(z < \frac{32-\mu}{\sqrt{16}}) = 0.5$ ✓

$\frac{32-\mu}{\sqrt{16}} = 0 \Rightarrow \boxed{\mu = 32}$

0.5 32 0.5

$\mu = 32$

Question 3: (20 points)
The in-control model for a certain quality characteristic ($\bar{x}$) is given by CL = 10, UCL = 13.09 and LCL = 6.91 with 0.001 probability limits and n = 4.
Estimate the process parameters μ and σ.

(1) $\mu = CL = 10$

$UCL = \mu + 3.09\, \sigma_{\bar{x}}$

$13.09 = 10 + 3.09\, \sigma_{\bar{x}}$ ✓

$3.09 = 3.09\, \sigma_{\bar{x}} \Rightarrow \sigma_{\bar{x}} = 1$

$\sigma_x = \sqrt{n} * \sigma_{\bar{x}}$

$\boxed{\sigma = 2}$ ✓

$6.91 = \mu - 3.0$

$13.09 = \mu + 3.0$

$20.\ldots = 2\mu$

(1) $\boxed{10 = \mu}$

What is the probability that a shift in mean to μ_{new} = 13.09 will be detected on the first sample following the shift?

2/10

$\mu_{new} = \mu_{old} + K\sigma_p$

$13.09 = 10 + K(2) \Rightarrow K = 3.09/2$

β = p(Point plot in side control limit / process is out of control)

$\beta = \Phi(3.09 - \frac{3.09}{2}(2)) - \cancel{\Phi(-3.09 - \frac{3.09}{2}(2))}$ 0

$\beta = 0.5$ ✓

p(shift will be detected on first sample) = p(point is out control limits) = 1-

= 0.

0.00135
0.9987

Question 4: (15 points)

An $\bar{x}$ control chart with 3-sigma limits has been constructed to monitor a certain quality characteristic. The following two rules are used to determine if the process is out of control:

a. If two consecutive sample points plot outside the control limits.

b. If three consecutive sample points plot above the center line.

i. What is α_1 associated with rule (a)?

$\alpha_1 = P(\text{2 points plot out side control Limit / process is in control})$

$= P(\text{first point plot out side / in-control}) * P(\text{second point plot out side / in control})$

$\alpha_1 = (P(X > UCL) + P(X < LCL))(P(X > UCL) + P(X < LCL))$

$\alpha_1 = (0.0027)(0.0027) = (0.0027)^2$

ii. What is α_2 associated with rule (b)?

$P(\text{point plots above center Line / process is in control}) = 0.5$

$\alpha_2 = P(P_1 \text{ plots above CL / in-control}) * P(P_2 \text{ plots above CL / in control}) * P(P_3 \text{ plot above / in control})$

$\alpha_2 = (0.5)^3$

iii. What is overall α associated with both rules?

$\alpha = 1 - (1-\alpha_1)(1-\alpha_2)$

$= 1 - ((1-(0.0027)(0.0027))(1-(0.5)^3))$

5/5

Question 5: (20 points)

Thirty samples each of size 9 have been collected. $\Sigma \bar{x}_i = 2700$ and $\Sigma R_i = 120$.
Construct the in control model for both $\bar{x}$ and R charts based on 3-sigma limits.

R-chart

$UCL = (120/30) \cancel{D_4} D_4 =$

$\bar{R} = CL = 120/30$

$LCL = (120/30) D_3 =$

R-chart

$(1.816)(120/30)$	=	$UCL = 7.264$
4	=	CL
$(4)(0.184)$	=	$LCL = 0.736$

If the R-chart was in control, estimate the process standard deviation.

$\bar{R} = d_2 \sigma_p$

$4 = (2.97)\sigma_p \Rightarrow \sigma_p = 4/2.97$

GOOD LUCK

$UCL = 90 + A_2 \bar{R} =$

$\bar{\bar{x}} = CL = 2700/30$

$\bar{x}$-chart

$90 + (0.337)(4)$	=	UCL	=	91.348
90	=	CL	=	90
$90 - (0.337)(4)$	=	LCL	=	89.652

$0.337 \times 4 = 1.348$

KAizen Team

Quality Control
(Quiz 1)

8.5

Student Name: ~~[illegible]~~ **ID:** ..7V7V7 **SR#:** 42

1% = The traditional definition(s) of quality is that

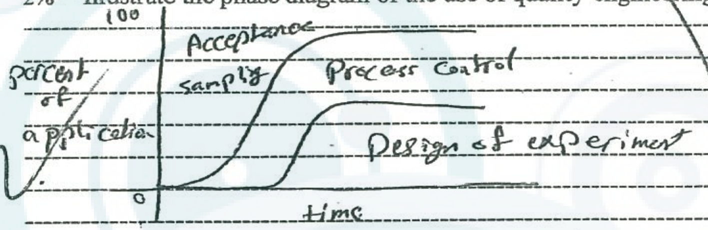
1. Collection of desirable a.c.H.
2. fitness for use.

1

1% = Quality costs are defined as: Categories of costs that are associated with Producing, identifying, avoiding or repairing products that not meet requirements

1

2% = Illustrate the phase diagram of the use of quality-engineering methods:



2

2% = A random sample of 50 units is drawn from a production process every two hours. What is the probability that the estimated fraction nonconforming is at most 2 % if the fraction nonconforming is really 0.04.

$n = 50 \qquad p = 0.04$

$\cancel{P(X \le 0.02)} \quad P(\hat{p} \le 0.04) \qquad \hat{p} = \frac{x}{n} \rightarrow 0.04 \ge \frac{x}{50}$

1

$P(X \le 2) = P(X=0) + P(X=1) + P(X=2) \qquad X < 2$

$\binom{50}{0}(0.02)^0(0.98)^{50} + \binom{50}{1}(0.02)^1(0.98)^{49} + \binom{50}{2}(0.02)^2(0.98)^{48} = 0.364 + 0.3716 + 0.186 = 0.9214$

2 % = A lightbulb has a normally distributed light output with mean 5,000 end foot-candles and standard deviation of 50 end foot-candles. Find the lower specification limit such that only 0.5 % of the bulbs will not exceed the limit.

$1 - 0.005 = 0.995$

$P\left(Z \le \frac{a-\mu}{\sigma}\right) = 0.005$

1.5

$\frac{a-\mu}{\sigma} = 2.58$

$\frac{a-5000}{50} = 2.58 \Rightarrow a = 5129$

$LSL = 2\mu - USL$

$= 10000 - 5129$

$\boxed{LSL = 4871}$

2% = Surface-finish defects in a small electric appliance occur at random with a mean rate of $\lambda =$ 0.1 defects per unit. Find the probability that a randomly selected unit will contain no surface-finish defects.

$P(X=0) = \frac{e^{-0.1}(0.1)^0}{0!}$

2

$= e^{-0.1} = 0.9048$

$P(\hat{p} \le 0.02) = P($

Quiz

Kaizen Team

10/10

Quiz (1) Quality Control

Date: 16/10/2008 Name: [redacted] ID: [redacted]

Q(1) What Is the traditional definition of quality? Mention three quality-engineering techniques used for reducing variability.

Fitness for Use

1) Design of Experiments
2) control Charts
3) acceptance Sampling

Q(2) A prduction process operates with % 2 nonconforming output. Every hour a sample of 20 units of product is taken, and the number of nonconforming units counted. If one or more nonconforming units are found, the sample is rejected.

$p = 0.02$
$n = 20$

1- Calculate the probability of rejecting the sample.

$P(x \geq 1) = 1 - P(X < 1)$

$1 - P(x=0) = 1 - \binom{20}{0}(0.02)^0(0.98)^{20} = 0.3323$

2- Using the poisson approximation, calculate the probability of detecting at least one nonconforming component. Is this approximation satisfactory? Why or why not?

$\boxed{p < 0.1} \rightarrow$ the apprx. is satisfactory

$\lambda = np = 20(0.02) = 0.4$

$P(x \geq 1) = 1 - P(X<1) = 1 - \frac{e^{-0.4}\,0.4^0}{0!} = 1 - 0.67 = 0.33$

Q(3) let x_1, x_2, x_3, and x_4 are exponential with parameter $\lambda = 3$ and independent. If y is defined as the sum of the four distributions.

(a) What is the distribution of y? Write the density function, f(y).

y is $\boxed{\text{Gamma}}$ distribution with $\lambda = 3$ & $r = 4$

$f(y) = \frac{\lambda x^{r-1} e^{-\lambda x}}{\Gamma(r)} = \frac{3x^3 e^{-3x}}{(4-1)!}$

(b) Calculate the mean and variance for the distribution in part (a).

$Mean = \frac{r}{\lambda} = \frac{4}{3} = 1.33\overline{3}$.

$Var = \frac{r}{\lambda^2} = \frac{4}{3^2} = \frac{4}{9} = 0.44\overline{4}$

Quiz

→ KAizen Team ←

8/10

Quality Control
(Quiz 1)

(2009) 2nd semester..

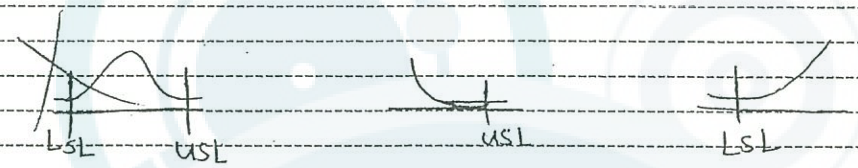
Student Name: --- ------ ID: - ------ SR#:---- --

1 1 % = The modern definition of quality is that -- Quality is inversely proportional to variability

1 % = There are two general aspects of fitness for use:
(1) quality of design
(2) quality of conformance.

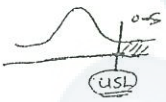
2% = Illustrate the application of quality-engineering techniques for systematic reduction of process variability:

0



2 % = A lightbulb has a normally distributed light output with mean 5,000 end foot-candles and standard deviation of 50 end foot-candles. Find the upper specification limit such that only 0.5 % of the bulbs will exceed the limit.

$\mu = 5000$, $\sigma = 50$



$P(X > USL) = 0.005 \Rightarrow P(X \le USL) = 1 - 0.005 = 0.995$

$P(Z \le \frac{USL - \mu}{\sigma}) = 0.995$

2 $Z \le 2.58$

$\frac{USL - 5000}{50} = 2.58$

$\boxed{USL = 5129}$

2 % = A random sample of 25 units is drawn from a production process every two hours. What is the probability that the estimated fraction nonconforming is at least 4 % if the fraction nonconforming is really 25 %. Binomial distribution

$= \binom{25}{0}(0.25)^0 (0.75)^{25}$
$= 0.0007525$
$\binom{25}{1} 0.25 (0.75)^{24}$

$n = 25$

$P(\hat{P} \ge 0.04) = P(\frac{X}{n} \ge 0.04) = P(\frac{X}{25} \ge 0.04) = P(X \ge 1)$ ✓

$= 1 - P(X < 1) = 1 - (\sum_{x=0}^{0} \binom{n}{x} (0.25)^x (0.75)^{n-x})$

~~= 1 - (P(X=0) + P(X=1))~~

2 ~~$P(\hat{P} \ge 0.04$~~ $= 1 - P(0) = 0.99924$

2% = Surface-finish defects in a small electric appliance occur at random with a mean rate of 0.1 defects per unit. Find the probability that a randomly selected unit will contain at least one surface-finish defects.

$\lambda = 0.1$

$P(X \ge 1) = 1 - P(X < 1) = 1 - P(0)$

2 $= 1 - \frac{e^{-0.1} (0.1)^0}{0!} = 1 - 0.9048$

$\boxed{P(X \ge 1) = 0.0952}$

Q2: (4 pts) The time to wear out of a cutting tool edge is distributed normally with $\mu = 2.8$ and $\sigma = 0.6$ hr.

(a) What is the probability that the tool will wear out in less than 1.5 hr?

$P(X < 1.5) = P(Z_0 < \frac{1.5 - 2.8}{0.6}) = P(Z < -2.33)$

$= 0.9$

(b) How often should the cutting edges be replaced to keep the failure rate less than 10 % of the tools?

$\mu = 1/\lambda \Rightarrow \lambda = 0.357$

Q3: (4 pts) The number of small business that fail each year is known to have a Poisson distribution with mean of 16. Find the probability that in a given year there will be no more than 18 small business failures using normal approximation. Is the approximation satisfactory? Why? Why not?.

$\sigma^2 = \mu = 16 = \lambda$ $\quad P(X \le 18) = P(Z_0 \le \frac{x - \mu}{\sigma})$

if satisfactory $= \lambda \ge 15$ $\quad = P(Z_0 \le \frac{18 - 16}{4}) = P(Z_0 \le 0.5)$

$16 \ge 15$ $\therefore$ Yes satisfactory $\quad = 0.69146$

Q4: (8 pts) The variabilities of the service times of two bank tellers are of interest. Their supervisor wants to determine whether the variance of service time for the first teller is greater than that for the second. A random sample of 8 observations from the first teller yields a sample average of 3.4 minutes and a sample standard deviation of 1.8. A random sample of 10 observations from the second teller yields a sample average of 2.5 minutes and a sample standard deviation of 0.9 minutes.

$\sigma_1^2 > \sigma_2^2$, $n_1 = 8$, $\bar{x}_1 = 3.4$, $S = 1.8$

(a) Can we conclude that the standard deviation of the service is greater for the first teller than the second teller? Use a level of significance α of 0.05.

① $n_1 = 8,\ \bar{x}_1 = 3.4,\ s_1 = 1.8$ ② $n_2 = 10,\ \bar{x} = 2.5,\ s = 0.9$

$H_0: \sigma_1^2 = \sigma_2^2 \quad H_1: \sigma_1^2 > \sigma_2^2 \quad F_0 = \frac{S_1^2}{S_2^2} = \frac{1.8^2}{0.9^2} = 4$

upper $= F_{\alpha/2, n_1 - 1, n_2 - 1} = F_{0.05, 7, 9} = 4.2$

$\therefore$ fail to reject $\quad \therefore \sigma_1^2 > \sigma_2^2$

(b) Test the hypothesis that the second bank teller provides larger mean service time than the first teller.

$H_0: \mu_1 = \mu_2$

$H_1: \mu_1 < \mu_2 \quad \Delta = 0$

② $v = \frac{\left(\frac{1.8^2}{8} + \frac{0.9^2}{10}\right)^2}{\frac{(1.8^2/8)^2}{9} + \frac{(0.9^2/10)^2}{11}} - 2 = 10.549 \approx 11$

① $t_0 = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} = \frac{3.4 - 2.5}{\sqrt{\frac{1.8^2}{8} + \frac{0.9^2}{10}}} = 1.291$

③ $-t_{\alpha/2, v} = -t_{0.025, 11} = 2.2$

-2.2

$\boxed{\therefore \text{ fail to reject } \therefore \mu_1 < \mu_2}$

(c) What is the approximate p-value in part (b).

lower $\Rightarrow \Phi t_0 = \Phi(1.291)$

if $\alpha >$ p-value $\Rightarrow$ we reject tolerance limits 9.4 a:2

unit → u-chart p.315

Q4 (10). Samples each of size seven have been collected to establish control over a process. The following data were collected:

$\mu = \frac{2700}{30} = 90$ $\sum_{i=1}^{30} \bar{x}_i = 2700$ $\sum_{i=1}^{30} R_i = 120$ $\bar{R} = \frac{120}{30} = 4$

$d_2 \to 2.702$

a:2 Calculate the natural tolerance limits.

$\sigma = \bar{R}/d_2$

$UCL = \mu + 3\sigma = 90 + 3(1.479) = 94.437$

$CL = \mu = 90$

$LCL = \mu - 3\sigma = 90 - 3(1.479) = 85.563$

$\hat{\sigma} = \frac{\bar{R}}{d_2}$

b:2 Suppose an s chart were desired. What would be the 3 sigma control limits and centerline?

$C_4 = 0.9594$ $\hat{\sigma} = \bar{S}/C_4 \to \bar{S} = 1.419$ $UCL = B_4\bar{S} = 2.67$

$CL = \bar{S} = 1.419$

$B_3 = 0.118$ $B_4 = 1.882$ p.253 $LCL = B_3\bar{S} = 0.167$

c:2 If the process mean shifts to $\boxed{85}$. What is the probability detect the shift by the fourth sample. $UCL = 91.7$ $LCL = 88$

$P(LCL < \bar{x} < UCL) = \left(\frac{88-85}{1.48/\sqrt{7}} < z < \frac{91.7-85}{1.48/\sqrt{7}}\right) = 0$ $UCL = \mu + 3\sigma$

$\hat{\sigma} = 1.48/\sqrt{7}\sqrt{n}$ $\sigma = \frac{\bar{R}}{d_2\sqrt{n}}$

$P(\text{detect by 4th sample}) = \beta^3(1-\beta) = 0$

d:2 Calculate the alpha error using the $\bar{x}$ and R charts. $\hat{\sigma} = \bar{R}/d_2\sqrt{n} = 0.559$ → very small

$\alpha = P(88.32 \le x \le 91.67) = 1 - [1 - P(\bar{x} \le 88.32) + P(\bar{x} \le 91.67)]$

$= 1 - [1 - P(z \le \frac{88.32-90}{0.559}) + P(z \le \frac{91.67-90}{0.559})] = 0.9998$

e:2 What is the average run length using an out of control s chart.

$ARL = \frac{1}{1-\beta} = \frac{1}{1-\text{zero}} = 1$

Q5(4). The number of nonconformities in carpets is determined for 20 samples, but the amount of carpets inspected for each sample varies. Suppose that the number of nonconformities is observed per 100 m². The total number of nonconformities is calculated 192. The total number of inspection units is 41. Assume average sample

a- Calculate the 3 sigma control limits and centerline. $n = \frac{\text{total}}{m}$

$\bar{u} = \frac{\sum c}{\sum n}$

$\bar{u} = \frac{192}{41} = 4.7$ $n = 41/20$ $UCL = \bar{u} + 3\sqrt{\frac{\bar{u}}{n}}$

$UCL = 4.7 + 3\sqrt{\frac{4.7}{2.05}} = 9.2171$ $CL = \bar{u}$

p.315

$LCL = 4.7 - 3\sqrt{\frac{4.7}{2.05}} = 0.1486$ $LCL = \bar{u} - 3\sqrt{\frac{\bar{u}}{n}}$

$n_1 = 4$, $n_2 = 2$

b- Suppose the two samples are found out of control with number of nonconformities of 20 and 10, respectively. The assignable cause of the first sample is determined and eliminated, but the cause of the second sample is considered to be occurred by chance. Determine the revised 3 sigma centerline and control limits.

$\bar{u} = \frac{172}{37} = 4.65$ $UCL = 4.65 + 3\sqrt{4.65/n_i}$

$CL = 4.65$

$\bar{n} = \frac{37}{19} = 1.9473$ $LCL = 4.65 - 3\sqrt{\frac{4.65}{n_i}}$

$\bar{c} = 182$

Q6(6). An assembled product consists of two parts. The first part is inserted in the second part with some clearance. The parts are produced in different machines and are assembled at random. Control charts are maintained on each dimension for the range of each sample of 5 sample size. 20 samples for the first part and 10 samples for the second part are used for range control chart. Given

x_2 x_1

$$\sum_{i=1}^{20} R_{1i} = 18.608 \qquad \sum_{i=1}^{10} R_{2i} = 6.978$$

$C = \mu_2 - \mu_1$

If it is desired that the probability of a smaller clearance than 0.09 should be 0.005.

a:2 Assuming that the dimensions are normally distributed, what is the distance between the average dimensions should be specified.

$C = \mu_1 - \mu_2$ $\quad P(C < 0.09) = 0.005$

$Z = -2.58 = 0.09 - \Delta$ $\quad \Leftarrow P\left(Z < \frac{0.09 - \Delta}{\sqrt{\sigma_1^2/n_1 + \sigma_2^2/n_2}}\right) = 0.05 \Rightarrow -2.58 = \frac{0.09}{0.2}$

$\boxed{d_2 = 2.326}$ $\quad \sqrt{\left(\frac{\bar{R}_1}{d_2}\frac{1}{n_1}\right)^2 + \left(\frac{\bar{R}_2}{d_2}\frac{1}{n_2}\right)}$ $\quad -0.57 = 0.09 - \Delta$ $\quad \boxed{\Delta = 0.667}$

$\sqrt{5} = 2.236$

b:2 Calculate the standard deviation for the assembled product.

$\sigma_1^2 = 0.03204$ $\quad \sigma_1 = \bar{R}_1 / d_2\sqrt{n_1} = \frac{(18.608)/20}{2.326 \cdot \sqrt{5}} = 0.179$ $\quad \sigma^2 = \sqrt{\sigma_1^2 + \sigma_2^2}$

$\sigma_2^2 = 0.01796$ $\quad \sigma_2^2 = \bar{R}_2 / d_2\sqrt{n_2} = ((6.978)/10) / 2.326 \cdot \sqrt{5} = 0.134$

$\sigma^2 = 0.05$

c:2 If the clearance should be less than 0.1, how much will the fraction of nonconforming assemblies if the estimated means difference from the parts control charts is 0.09.

$P(C > 0.1) = P\left(Z > \frac{0.1 - 0.09}{\sqrt{\left(\frac{\bar{R}_1}{d_2}\right)^2 + \left(\frac{\bar{R}_2}{d_2}\right)^2}}\right) = P\left(Z > \frac{0.1 - 0.09}{\sqrt{(0.4)^2 + (0.3)^2}}\right) = P(Z > 0.)$

$= P(Z > 0.$

$= 0.508$

Q7(5). A process is in control with $\bar{\bar{x}} = 199$ and $\bar{R} = 3.5$ obtained with a sample size of 4. Specifications are 200±8. Assume the quality characteristic is normally distributed.

$\hat{\sigma} = \bar{R}/d_2$ $\quad d_2 = 2.059$

a:0.5 Estimate the potential process capability

$C_p = \frac{USL - LSL}{6\sigma} = \frac{208 - 192}{6 \cdot \left(\frac{3.5}{2.059}\right)} = 1.5696$ $\quad \hat{\sigma} = 1.700$ $\quad \bar{R}/d_2$

b:0.5 Estimate the actual process capability

$C_{pk} = \min\left\{\frac{208 - 199}{3 \cdot (1.7)}, \frac{199 - 192}{3 \cdot (1.7)}\right\} = 1.373$

c:2 How much improvement could be made in process performance if the mean could be centered at the nominal value?

$C_{pkm} = 1.1832$ after Centering $C_p = C_{pk} = C_{pkm} = 1.5696$

d:2 Suppose you want to increase the sensitivity to mean shift, calculate the proper process capability index.

$C_{pkm} = \frac{C_{pk}}{\sqrt{1 + \xi^2}} = \frac{1.373}{\sqrt{1 + \left(\frac{199 - 200}{1.7}\right)^2}} = 1.183$

$\bar{\bar{x}} = 199$ $\quad \bar{R} = 3.5$ $\quad n = 4$ $\quad USL = 208$ $\quad LSL = 192$

1.75 1.3 1.5 1.16

$\mu_0 =$ $\quad \frac{199 - \mu}{1.7}$ $\quad \frac{199 - 200}{1.7}$

Q5: (5 pts) The tuft bind strength of a synthetic material used to make carpets is known to have a mean of 50 kg and a standard deviation of 10 kg. If a sample of size 36 is randomly selected. Use a level of significance α of 0.05.

$\mu = 50$, $\sigma = 10$, $n = 36$, $\alpha = 0.05$

(a) What is the probability that the sample mean will be less than 52.5 kg?

$P(\bar{x} \le 52.5) = P\left(Z_0 \le \frac{52.5 - 50}{10/6}\right)$

$\frac{\bar{X} - \mu}{\sigma/\sqrt{n}}$

$P(Z_0 \le 1.5)$

$= 0.93319$

5

2

(b) Construct a 95 % upper-sided confidence interval on the mean tuft bind strength. $z_{0.05}$ 1.645

$\mu \le \bar{x} + z_\alpha \sigma/\sqrt{n}$

$\mu \le 52.5 + 1.645 \times 10/6 = 55.24$

2

$\mu \le 55.24$

$\mu \le \bar{x} + z_\alpha \sigma/\sqrt{n}$

(c) If the true mean is 48 kg, what will be the consumer's risk? $\beta =$ $\delta = 50 - 48 = 2$

$\mu = 48$

$\beta = \Phi\left(z_{\alpha/2} - \frac{\delta\sqrt{n}}{\sigma}\right) - \Phi\left(-z_{\alpha/2} - \frac{\delta\sqrt{n}}{\sigma}\right)$

$= \Phi\left(1.96 - \frac{2\times 6}{10}\right) - \Phi\left(-1.96 - \frac{2\times 6}{10}\right) = \Phi(0.76) - \Phi(-3.16)$

$\beta = \Phi(0.76) - [1 - \Phi(3.16)]$

$= 0.77558$

2

3

Q6: (4 pts) An automated machine is used to fill bottles with liquid detergent. A random sample of 20 bottles results in a sample variance of fill volume of 0.0153 (fluid ounces)^2. If the variance of fill volume exceeds 0.01 (fluid ounces)^2, an unacceptable proportion of bottles will be underfilled or overfilled.

$n = 20$, $s^2 = 0.0153$, $(\sigma^2 > 0.01)$

(a) Is there evidence in the sample data to suggest that the manufacturer has a problem with underfilled or overfilled? Use α of 0.05, and assume that fill volume has a normal distribution?

$H_0: \sigma^2 = 0.01$

$H_1: \sigma^2 > 0.01$

① $\chi_0^2 = \frac{19 \times 0.0153}{0.01} = 29.07$

② $\chi^2_{1-\alpha, n-1} = \chi^2_{0.95, 19} = 10.12$

10.12 $\chi_0^2 > \chi^2_{\alpha, n-1}$

2

$\therefore$ fail to reject H_0

(b) Construct a 95 % lower-sided confidence interval on the standard deviation of fill volume.

$\frac{(n-1)s^2}{\chi^2_{1-\alpha, n-1}} \le \sigma^2 = \frac{19 \times 0.0153}{10.12} = 0.0287$

$\chi^2_{0.95, 19}$

8

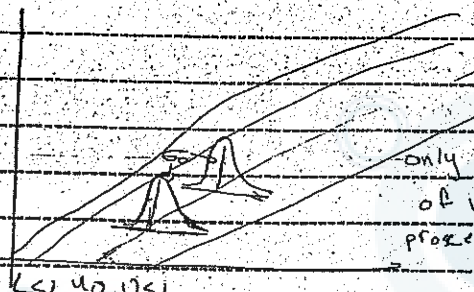
1

$0.0287 \le \sigma^2$

$0.169 < \sigma^2$

$\chi^L < \sigma^2 < \chi^U$

Q2: (3 pts) Illustrate chance and one assignable cause of variations. p.182



3

Q3: (3 pts) The stem and leaf and the histogram provide visual impression about set of data, ignores time series p.71, whereas the sample average and standard deviation provide visual display of 3 properties of sample data. The box plots displays several important feature of data such as location, spread or variability, departure from symmetry

several important features of data such as CT, spread, outliers, symmetry

1

quantitative information about features of data

Q4: (9 pts) The length of a mechanical part is known to have a normal distribution with a mean 100 mm and a standard deviation of 2mm.

$\mu = 100 \quad \sigma = 2$

(a) What proportion of the parts will be above 103.3mm?

$p(x > 103.3) = 1 - p(x \le 103.3)$

$= 1 - p\left(z \le \frac{103.3 - 100}{2}\right)$

$= 1 - \Phi(1.65)$

$= 0.04947$

3

(b) If a sample size 4 is randomly selected, what is the probability that the sample mean will be less than 101mm?

$n = 4$

$\mu < 101$

$p(x < 101) = p\left(z < \frac{x - \mu}{\sigma/\sqrt{n}}\right) = p\left(z < \frac{101 - 100}{2/\sqrt{4}}\right) = p(z \le 1)$

$= 0.84134$

3

?

(c) It is important that not many of the parts exceed the desired length. If the manager stipulates that no more than 5 % of the parts should be oversized, what specification limit should be recommended?

$p(X \le 0.05)$

x chi-square dist.

$\sigma^2 \le \frac{(n-1)s^2}{\chi^2_{1-\alpha, n-1}}$

$\sigma^2 \le \frac{(3)2}{\chi^2_{0.95, 3}} = \frac{6}{0.35} = 17.1$

10

8

Sorry for not giving the final answer But there was no time.

Q 5: (9 pts) Consider a lot of 100 parts, of which 94 are conforming. If a sample of 4 parts is selected,

(a) What is the probability of obtaining 2 nonconforming items? $N=100$ $D=94$ $n=4$

hyper-Geometric

$x=2$

$$p(x=2) = \frac{\binom{94}{2}\binom{100-94}{4-2}}{\binom{100}{4}}$$

?? 4 (b) If a binomial approximation is used, what is the required probability in part (a)? Is the approximation satisfactory?

$p=\frac{D}{N}$ $p=\frac{94}{100}=0.94$

Binomial

$p(x=2)=\binom{4}{2}0.94^2\ 0.06^2$ $\frac{n}{N}<0.1$ $\frac{4}{100}<0.1$ $0.04<0.1$ $p=0.94 \leq 0.1$ $0.94>0.1$ not it's not satisfactory

(c) If a Poisson distribution is used, calculate the probability in part (b). Is the approximation satisfactory?

$\lambda = np = 4 \cdot 0.94$ $\mu=\sigma^2=\lambda=3.76$

$p(x=2)=\frac{e^{-3.76}\,3.76^2}{2!}$ $\lambda \geq 15$ $\lambda \leq 15$ $3.76 \leq 15$ not satisfactory

Q6 (12 pts) A component is known to have an exponential time-to-failure distribution with a mean life of 10,000 hours.

(a) What is the probability of the components lasting at least 8000 hours? $\lambda=10{,}000$ λ

2 $p(x \geq 8000) = 1-p(x\leq 8000)$

$=1-e^{-\lambda t}=0.55$ $1-e^{-10{,}000\times 8000}$

Before failure ~~0.6.3212~~

?? (b) If the component is in operation at 9000 hours, what is the probability that it will last another 6000 hours?

memory less

$\int_0^{6000}\lambda e^{-\lambda x}dx = 10{,}000e^{-1000x}\Big|_0^{6000}$

?? (c) Two such components are put in parallel, so that the system will be in operation if at least one of the components is operational. What is the probability of the system being operational for 12000 hours? Assume that the components operate independently.

$p(x=1)=\lambda e^{-\lambda x}=1200e^{-1200(1)}$ $p(1)+p(2)$ $p(x=1)+p(x=2)$

$p(x=1)+p(x=$

$f(x)=\lambda$

(d) If the two components are operating in a system standby redundant system. Calculate the mean and standard deviation of system life.

2 $\mu=\frac{1}{\lambda}=\frac{1}{1200}=8.3\times10^{-4}$

$\sigma^2=\frac{1}{\lambda^2}$

$\sigma=\sqrt{\frac{1}{\lambda^2}}=\sqrt{\frac{1}{1200^2}}=8.3\times10^{-3}$

8