UNIT - 5

AAYUSHI...

1. CONFIDENCE INTERVAL

1> $n = 100$, $\bar{x} = 498\ ml$
$\sigma = 10ml$, $\alpha = 1 - 0.95 = 0.05$

$Z_{\alpha/2} = 1.96$

Margin of error $= Z_{\alpha/2}\left(\frac{\sigma}{\sqrt{n}}\right)$

$= 1.96\left(\frac{10}{\sqrt{100}}\right) = 1.96$

Lower limit $= 498 - 1.96 = 496.04$

Upper limit $= 498 + 1.96 = 499.96$

2.> $n = 150$, $\bar{x} = 2.02kg$,
$\sigma = 0.1kg$ $\quad Z_{\alpha/2} = 2.576$

margin of error(ME)

$= 2.576\left(\frac{0.1}{\sqrt{150}}\right) = 0.021$

lower limit $= 2.02 - 0.021$
$= 1.999\ kg$

Upper limit $= 2.02 + 0.021$
$= 2.041\ kg$

3.> $n = 9$

mean $= \frac{6.5 + 7 + 6.8 + 5.9 + 7.1 + 6.3 + 7.4 + 6 + 6.7}{9}$

$= \cancel{7.744}\ \frac{59.7}{9} = 6.633\ hrs$

$s.d = 0.505\ hrs$

degree of freedom df $= n-1$
$= 9 - 1 = 8$

$t_{\alpha/2}\left(\frac{sd}{\sqrt{n}}\right)$

$ME = 2.306\left(\frac{0.505}{\sqrt{9}}\right) = 0.388$

Lower limit $= 6.633 - 0.388$
$= 6.245\ hrs$

Upper limit $= 6.633 + 0.388$
$= 7.021\ hrs$

4.> $n = 7$

mean $\bar{x} = \frac{12 + 15 + 14 + 10 + 13 + 11 + 16}{7}$

$= \frac{91}{7} = 13$

standard deviation : $s = 2.16$ days

Degree of freedom $\Rightarrow df = n - 1$
$= 7 - 1 = 6$

confidence level $= 90\%$

$t_{\alpha/2} = 1.943$

$ME = t_{\alpha/2}\left(\frac{s}{\sqrt{n}}\right) = 1.943\left(\frac{2.16}{\sqrt{7}}\right)$
$= 1.586$

Lower limit $= 13 - 1.586 = 11.414$

Upper limit $= 13 + 1.586 = 14.586$

5> $n = 500$, $x = 285$, $\hat{p} = \frac{x}{n} = \frac{285}{500}$
$= 0.57$

Confidence level $= 95\%$

$Z_{\alpha/2} = 1.96$

$ME = Z_{\alpha/2}\sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$

$= 1.96\sqrt{\frac{0.57(1-0.57)}{500}} = 0.0434$

Lower limit $= 0.57 - 0.0434$
$= 0.5266$

Upper limit $= 0.57 + 0.0434$
$= 0.6134$

6.> $n = 120$, $x = 18$, $p = \frac{18}{120} = 0.15$

Confidence level $= 99\%$

$\alpha = 0.01$, $\frac{\alpha}{2} = 0.005$

$Z_{\alpha/2} = Z_{0.005} = 2.576$

standard error $= \sqrt{\frac{\hat{p}(1-\hat{p})}{n}} = \sqrt{\frac{0.15(1-0.15)}{120}}$
$= 0.0326$

$ME = Z_{\alpha/2} \times SE$
$= 2.576 \times 0.0326$
$= 0.0839$

Lower limit $= 0.15 - 0.0839$
$= 0.0661$
Upper limit $= 0.15 + 0.0839$
$= 0.2339$

7) $n = 10$, $df = n-1 = 9$
$s^2 = 4.5 mm^2$
$\alpha = 0.05$
$\chi^2_{1-\alpha/2, df} = \chi^2_{0.975, 9} = 2.70$
$\chi^2_{\alpha/2, df} = \chi^2_{0.025, 9} = 19.02$
Lower bond $= \frac{(n-1)s^2}{\chi^2_{\alpha/2, df}} = \frac{(10-1)\times 4.5}{19.02}$
$\approx 2.129 mm^2$
Upperbond $= \frac{(n-1)s^2}{\chi^2_{1-\alpha/2, df}} = \frac{(10-1)\times 4.5}{2.70}$
$= 15 mm^2$

8) $n = 16$, $df = n-1 = 15$
std deviation : $s = 1.2 N$
$s^2 = 1.44 N^2$
$\alpha = 0.01$
$\chi^2_{1-\alpha/2, df} = \chi^2_{0.995, 15} = 4.60$
$\chi^2_{\alpha/2, df} = \chi^2_{0.005, 15} = 32.80$
Lower bound $= \frac{(n-1)s^2}{\chi^2_{\alpha/2 df}} = \frac{(16-1)\times 1.44}{32.80}$
$= \frac{21.6}{32.8} = 0.659 N^2$
Upper bound $= \frac{(n-1)s^2}{\chi^2_{1-\alpha/2, df}}$
$= \frac{(16-1)\times 1.44}{4.60} = \frac{21.6}{4.6} = 4.696 N^2$

9) $n_A = 12$, $df_A = 11$, $s^2_A = 18.2$
$n_B = 10$, $df_B = 9$, $s^2_B = 10.5$

confidence level $= 90\%$. $\alpha = 0.10$
$F_{\alpha/2, df_A, df_B} = F_{0.05, 11, 9} = 3.10$
$F_{1-\alpha/2, df_A, df_B} = F_{0.95, 11, 9} = 0.345$
$F_{\alpha/2, df_B, df_A} = F_{0.05, 9, 11} = 2.90$
$\frac{S^2_A}{S^2_B} = \frac{18.2}{10.5} = 1.733$
Lower bound $= \frac{1.733}{3.10} = 0.559$
Upper bound $= 1.733 \times 2.90$
$= 5.026$

10) $n_1 = 14$, $s_1^2 = 0.022 mm^2$
$df_1 = n_1 - 1 = 13$
$n_2 = 16$, $s_2^2 = 0.015 mm^2$
$df_2 = n_2 - 1 = 15$
$\alpha = 1 - 0.98 = 0.02$
$\alpha/2 = 0.01$
$F_{\alpha/2, df_1, df_2} = F_{0.01, 13, 15} = 3.84$
$F_{1-\alpha/2, df_1, df_2} = F_{0.99, 13, 15} = \frac{1}{F_{0.01, 15, 13}}$
$= \frac{1}{4.25} = 0.235$
$\frac{\sigma_1^2}{\sigma_2^2} = \left(\frac{S_1^2}{S_2^2}\frac{1}{F_{\alpha/2, df_1, df_2}}, \frac{S_1^2}{S_2^2}\frac{1}{F_{1-\alpha/2, df_1, df_2}}\right)$
$= \left(\frac{0.022}{0.015}\frac{1}{3.84}, \frac{0.022}{0.015}\frac{1}{0.235}\right)$
$= (0.3819, 6.2415)$

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2. TYPE - I & TYPE - II ERROR

1) a) $p = 0.4$, $n = 12$

$x \leq 2$

$P(X=k) = {}^nC_k \; p^k (1-p)^{n-k}$

$P(x=0) = {}^{12}C_0 (0.4)^0 (0.6)^{12}$
$= 0.00218$

$P(X=1) = {}^{12}C_1 (0.4)^1 (0.6)^{11}$
$= 0.01743$

$P(X=2) = {}^{12}C_2 (0.4)^2 (0.6)^{10}$
$\simeq 0.05634$

$\alpha = 0.00218 + 0.01743 + 0.05634$
$= 0.07595$

b) $p = 0.2$

$x \geq 3$

$\beta = P(X \geq 3 \mid p = 0.2)$
$= 1 - P(X \leq 2 \mid p = 0.2)$

$P(X \leq 2 \mid P = 0.2)$

$P(x=0) = {}^{12}C_0 (0.2)^0 (0.8)^{12}$
$= 0.06872$

$P(X=1) = {}^{12}C_1 (0.2)^1 (0.8)^{11}$
$= 0.20615$

$P(X=2) = {}^{12}C_2 (0.2)^2 (0.8)^{10}$
$= 0.28347$

$P(X \leq 2) = 0.06872 + 0.20615 + 0.28347$
$= 0.55834$

$\beta = 1 - 0.55834 = 0.44166$

2) a) $\alpha = P(\bar{X} < 96.9 \mid \mu = 100)$ $n = 25$

$\mu_0 = 100$, $\sigma_{\bar{x}} = \dfrac{\sigma}{\sqrt{n}} = \dfrac{10}{\sqrt{25}} = 2$

$\cancel{\bar{x}} \; \bar{x} = 96.9$ AAYUSHI PRIYA

$z = \dfrac{\bar{x} - \mu_0}{\sigma_{\bar{x}}} = \dfrac{96.9 - 100}{2} = -1.55$

$\alpha = P(Z < -1.55) = 0.0606$

b) $\mu = 95$, acceptance region $\bar{x} \geq 96.9$

$Z = \dfrac{\bar{x} - \mu}{\sigma / \sqrt{n}} = \dfrac{96.9 - 95}{10/\sqrt{25}} = 0.95$

$\beta = P(Z \geq 0.95) = 1 - P(Z < 0.95)$
$= 1 - 0.8289 = 0.1711$

3) a) $p = 0.6$, $n = 50$

$x \leq 24.5$

$\mu_x = np = 50 \times 0.6 = 30$

$\sigma_x = \sqrt{np(1-p)} = \sqrt{50 \times .6 \times .4}$
$= 3.464$

$Z = \dfrac{x - \mu_x}{\sigma_x} = \dfrac{24.5 - 30}{\sqrt{12}} = -1.5877$

$P(Z \leq -1.5877) \approx 0.056$

b) $p = 0.3$, $x \geq 24.5$

$\mu_x = np = 50 \times 0.3 = 15$

$\sigma_x = \sqrt{np(1-p)} = \sqrt{50 \times .3 \times .7} = 3.24$

$Z = \dfrac{x - \mu_x}{\sigma_x} = \dfrac{24.5 - 30}{\sqrt{12}} = -1.5877$

4) a) $|\bar{x} - 1000| > 1.96 \dfrac{5}{\sqrt{25}}$

$\dfrac{|\bar{x} - \mu_0|}{\sigma/\sqrt{n}} > 1.96$

$\mu_0 = 1000$, $\sigma = 5$, $n = 25$

$|z| > 1.96$

$\alpha = P(|z| > 1.96)$

$P(|z| > 1.96) = 2 \cdot P(z < -1.96)$
$= 2 \cdot P(z > 1.96)$
$= 2 \times 0.025 = 0.05 = 5\%$

b) $\mu_1 = 998.5$ AAYUSHI PRIYA

$|\bar{x} - 1000| \le 1.96 \cdot \frac{5}{\sqrt{25}}$

$1.96 \cdot \frac{5}{\sqrt{25}} = 1.96$

$\bar{x} > 1000 + 1.96$ or $\bar{x} < 1000 - 1.96$

$\bar{x} > 1001.96$ or $\bar{x} < 998.04$

$998.04 \le \bar{x} \le 1001.96$

~~$\mu_1 = 9.$~~

$\beta = P(998.04 \le \bar{x} \le 1001.96 | \mu_1 = 998.5)$

$\frac{\sigma}{\sqrt{n}} = 1$: $Z_1 = \frac{998.04 - 998.5}{1} = -0.46$

$Z_2 = \frac{1001.96 - 998.5}{1} = 3.46$

$\beta = P(Z_1 \le Z \le Z_2) = P(-0.46 \le Z \le 3.46)$

$\beta = P(Z \le 3.46) - P(Z \le -0.46)$

$= 0.9997 - 0.3228$

$= 0.6769 = 67.69\%$.

3. Z-TEST

1). $H_0: \mu = 150$, $H_1: \mu \ne 150$

$\sigma = 5$, $n = 36$, $\bar{x} = 148.5$, $\alpha = 0.05$

a) $Z = \frac{\bar{x} - \mu}{\sigma/\sqrt{n}} = \frac{148.5 - 150}{5/\sqrt{36}} = -1.8$

$\alpha = 0.05$, $Z_{\alpha/2} = \pm 1.96$

$Z = -1.8$ is b/w -1.96 & 1.96

Fail to reject null hypothesis $H_0: \mu = 150$ at 5% level of significance

b) $P = 2 \times P(Z < |z|)$

$= 2 \times P(Z < -1.8) = 2 \times 0.0359$

$= 0.0718$

2. $H_0: \mu = 25$, $H_1: \mu < 25$

$\sigma = 2$, $n = 49$, $\bar{x} = 24.4$, $\alpha = 0.01$

$Z = \frac{\bar{x} - \mu}{\sigma/\sqrt{n}} = \frac{24.4 - 25}{2/\sqrt{49}} = -2.1$

$\alpha = 0.01$, $Z_\alpha = -2.33$

$Z = -2.1$

We fail to reject null hypothesis $H_0: \mu = 25$ at 1% level of significance.

3. $H_0 \Rightarrow \mu = 5000$, $H_1: \mu \ne 5000$

$n = 100$, $\bar{x} = 4950$, $s = 120$,

$\alpha = 0.05$, $n \ge 30$.

$Z = \frac{\bar{x} - \mu}{s/\sqrt{n}} = \frac{4950 - 5000}{120/\sqrt{100}} = -4.167$

$Z_{\alpha/2} = \pm 1.96$

$Z = -4.167$

$H_0: \mu = 5000$ at 5% level of significance

4. $H_0: \mu = 2$, $H_1: \mu < 2$

$n = 64$, $\bar{x} = 1.98$, $s = 0.08$, $\alpha = 0.01$

$Z = \frac{\bar{x} - \mu}{s/\sqrt{n}} = \frac{1.98 - 2}{0.08/\sqrt{64}} = -2$

$\alpha = 0.01$, $Z_\alpha = -2.33$

$Z = -2$

We fail to reject null hypothesis $H_0: \mu = 2$ at 1% level of significance

5. $H_0: p = 0.6$, $H_1: p \ne 0.60$

$\alpha = 0.05$

$n = 200$, $x = 108$, $\hat{p} = \frac{x}{n} = \frac{108}{200} = 0.54$

standard error : $SE = \sqrt{\frac{P_0(1-P_0)}{n}} = \sqrt{\frac{0.6(1-0.6)}{200}}$

$= 0.03464$

$Z = \frac{\hat{p} - p_0}{\sqrt{\frac{P_0(1-P_0)}{n}}} = \frac{0.54 - 0.6}{\sqrt{\frac{0.6(1-0.6)}{200}}} = -1.732$

~~Z~~ $= \pm 1.96$

$Z = -1.732$

$2 \times P(Z < -|Z|)$

p-value $= 2 \times P(Z < 1.732)$

$= 2 \times 0.0416 = 0.0832$

6> $H_0: p = 0.05$, $H_1: p > 0.05$

$n = 400$, $x = 28$

$\hat{p} = \frac{28}{400} = 0.07$ $\alpha = 0.01$

$$z = \frac{\hat{p} - p_0}{\sqrt{\frac{p_0(1-p_0)}{n}}} = \frac{0.07 - 0.05}{\sqrt{\frac{0.05(1-0.05)}{400}}} = 1.835$$

z - value is approx 2.33

$z \simeq 1.835$

$P(z > 1.835) \simeq 0.0332$

4. t - TEST

1> $\mu_0 = 500mg$, $n = 9$, $\bar{x} = 485mg$

$s = 20mg$, $\alpha = 0.05$

$H_0: \mu = 500$ & $H_1: \mu \neq 500$

$$t = \frac{\bar{x} - \mu_0}{s/\sqrt{n}} = \frac{485 - 500}{20/\sqrt{9}} = -2.25$$

$df = n - 1 = 9 - 1 = 8$

$\alpha = 0.05$

t values are $\pm t_{\alpha/2, df} = \pm t_{0.025, 8}$

$= \pm 2.306$

$t = -2.25$

$(-2.306 < -2.25 < 2.306)$

we donot reject null hypothesis

2. $H_0: \mu = 100$; $H_1: \mu < 100$

$\alpha = 0.01$, $n = 12$, $\bar{x} = 96.5$

$$t = \frac{\bar{x} - \mu_0}{s/\sqrt{n}} = \frac{96.5 - 100}{8/\sqrt{12}} = -1.516$$

$df = n - 1 = 12 - 1 = 11$

$\alpha = 0.01$, $-t_{\alpha, df} = -t_{0.01, 11}$

$= -2.718$

$t = -1.516$

$(-1.516 > -2.718)$

we donot reject H0. Avg battery life is less than 100 hrs at 1% level of significance.

3. $H_0: \mu = 70$, $H_1: \mu > 70$

$\alpha = 0.05$, $n = 10$, $\bar{x} = 74$, $s = 5$

$$t = \frac{\bar{x} - \mu_0}{s/\sqrt{n}} = \frac{74 - 70}{5/\sqrt{10}} = 2.53$$

$df = n - 1 = 10 - 1 = 9$

$t_{\alpha, df} = t_{0.05, 9} = 1.833$

$t = 2.53 > 1.833$

We reject H_0.

5. χ^2 TEST

1> $H_0: \sigma^2 = 0.04$, $H_1: \sigma^2 \neq 0.04$

$\alpha = 0.05$ $s^2 = 0.06$, $n = 10$

$$\chi^2 = \frac{(n-1)s^2}{\sigma^2} = \frac{(10-1)0.06}{0.04} = 13.5$$

$df = n - 1 = 10 - 1 = 9$

$\chi^2_{1-\alpha/2} = \chi^2_{0.975}$ $\chi^2_{\alpha/2} = \chi^2_{0.025}$

$\chi^2_{0.975} = 2.70$ $\chi^2_{0.025} = 19.02$

$\chi^2 < 2.70$ or $\chi^2 > 19.02$

$\chi^2 = 13.5$ $(2.7 < 13.5 < 19.02)$

donot reject H_0.

2. $H_0: \sigma^2 \leq 0.0025$, $H_1: \sigma^2 > 0.0025$

$\alpha = 0.05$, $n = 20$, $s^2 = 0.004$,

$\sigma^2 = 0.0025$

$$\chi^2 = \frac{(n-1)s^2}{\sigma^2} = \frac{(20-1)0.004}{0.0025} = 30.4$$

$df = n - 1 = 20 - 1 = 19$

$\chi^2_\alpha = \chi^2_{0.05} \simeq 30.14$

$\chi^2 > 30.14$

$30.4 > 30.14$

Reject H_0

3. $H_0: \sigma^2 \leq 0.01$, $H_1: \sigma^2 > 0.01$

$\alpha = 0.05$

$\chi^2 = \frac{(n-1)s^2}{\sigma^2}$ $n = 12$, $s^2 = 0.015$,

$\sigma^2 = 0.01$

$$\chi^2 = \frac{(12-1) \times 0.015}{0.01} = 16.5$$

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$df = n-1 = 12-1 = 11$

$\chi^2_\alpha = \chi^2_{0.05} = 19.68$

$(16.5 < 19.68)$

We donot reject null hypothesis

6. F-TEST

1> $(\sigma^2_A = \sigma^2_B)$

$F = s^2_B / s^2_A$ $\quad s^2_B$ is larger

$n_A = 10,\ s^2_A = 0.002\,cm^2,\ n_B = 11,$

$s^2_B = 0.005\,cm^2,\ \alpha = 0.10$

$df_B = n_B - 1 = 10$

$df_A = n_A - 1 = 9$

$F_{\alpha/2}$ is $F_{0.05,10,9} = 3.259$

$$F = \frac{S^2_B}{S^2_A} = \frac{0.005}{0.002} = 2.5$$

$2.5 < 3.259$ we don't reject null hypotesis.

2> $F = s^2_Y / s^2_X$

$n_X = 8,\ S^2_X = 1.5,\ n_Y = 10,\ S^2_Y = 2.8$

$\alpha = 0.01$

$df_Y = n_Y - 1 = 9 \quad df_X = n_X - 1 = 7$

$F_{0.01,9,7} \simeq 6.71$

$$F = \frac{S^2_Y}{S^2_X} = \frac{2.8}{1.5} \simeq 1.867$$

$1.867 < 6.71$.

Do not reject null hypothesis

3> $n_A = 8,\ S^2_A = 20,\ n_B = 7,\ S^2_B = 12$

$\alpha = 0.05$

$df_A = n_A - 1 = 7,\ df_B = n_B - 1 = 6$

$F_{0.05,7,6} \simeq 4.21$

$$F = \frac{S^2_A}{S^2_B} = \frac{20}{12} \simeq 1.667$$

$1.667 < 4.21$

$\therefore$ At 5% significant level, not enough evidence to conclude method A has greater variance than method B.

4> $n_A = 10$

$$\bar{x}_A = \frac{10.2+10.4+10.1+10.5+10.3+10.2+10.4+10.3+10.1+10.2}{10}$$

$= 10.27\,mm$

$S^2_A \simeq 0.019\,mm^2$

$n_B = 12$

$$\bar{x}_B = \frac{10.7+10.9+10.8+10.6+11.0+10.9+10.7+10.8+10.9+11.1+10.8+10.7}{12}$$

$= 10.825\,mm$

$S^2_B = 0.017\,mm^2$

$\alpha = 0.10$

$df_A = n_A - 1 = 9 \quad df_B = n_B - 1 = 11$

$F_{0.05,9,11} \simeq 2.90$

$$F = \frac{S^2_A}{S^2_B} = \frac{0.019}{0.017} = 1.118$$

$$F_{0.95,9,11} = \frac{1}{F_{0.05,11,9}} \simeq \frac{1}{3.10} = 0.32$$

$0.32 < 1.5 < 2.90$

At 10% significant level, we fail to reject null hypothesis

5> $H_0 : \sigma^2_A \leq \sigma^2_B$

$H_1 : \sigma^2_A > \sigma^2_B \quad \alpha = 0.01$

$n_A = 15,\ n_B = 15$

$\bar{x}_A = 83.87 \quad \bar{x}_B = 77.2$

$S^2_A = 14.98 \quad S^2_B = 4.4$

$$F = \frac{S^2_A}{S^2_B} = \frac{14.98}{4.4} = 3.405$$

$df_A = n_A - 1 = 14$; $df_B = n_B - 1 = 14$

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$F_{0.01, 14, 14} = 3.70$

$3.405 < 3.70$ $\therefore$ we fail to reject null hypothesis

7. GOODNESS-OF-FIT

1) $p = 0.5$, $N = 240$, $n = 4$

$P(X=k) = {}^nC_k \, p^k (1-p)^{n-k}$

$E_k = N \times P(X=k)$

$k=0$

$E_0 = 240 \cdot {}^4C_0 (0.5)^0 (0.5)^4$
$= 15$

$k=1$
$E_1 = 240 \cdot {}^4C_1 (0.5)^1 (0.5)^3 = 60$

$k=2$
$E_2 = 240 \times {}^4C_2 (0.5)^2 (0.5)^2 = 90$

$k=3$
$E_3 = 240 \times {}^4C_3 (0.5)^3 (0.5)^1 = 60$

$k=4$
$E_4 = 240 \times {}^4C_4 (0.5)^4 (0.5)^0 = 15$

no. of heads	observed (O_i)	Expected (E_i)	$\frac{(O_i-E_i)^2}{E_i}$
0	9	15	$(9-15)^2/15 = 2.4$
1	32	60	$(32-60)^2/60 = 13.07$
2	72	90	$(72-90)^2/90 = 3.6$
3	85	60	$(85-60)^2/60 = 10.42$
4	42	15	$(42-15)^2/15 = 48.6$

$\chi^2_{calc} = 2.4 + 13.07 + 3.6 + 10.42 + 48.6 = 78.09$

$df = k - p - 1 = 5 - 0 - 1 = 4$

At 5% level of significance

$\alpha = 0.05$ $df = 4$

$\chi^2_{crit} = 9.488$

$\chi^2_{calc} = 78.09 > \chi^2_{crit} = 9.488$

We reject null hypothesis

2) $N = 80$

$\bar{x} = \frac{30.0 + 28.1 + 16.2 + 6.3}{80} = 0.975$

$P(X=k) = \frac{e^{-\lambda} \lambda^k}{k!}$

$E_k = N \times P(X=k)$

$k=0$
$E_0 = \frac{80 \times e^{-0.975} (0.975)^0}{0!} = 30.17$

$k=1$
$E_1 = \frac{80 \times e^{-0.975} (0.975)^1}{1!} = 29.38$

$k=2$
$E_2 = \frac{80 \times e^{-0.975} (0.975)^2}{2!} = 14.34$

$k=3$
$E_3 = \frac{80 \times e^{-0.975} (0.975)^3}{3!} = 4.66$

Observed (O_i) : $16 + 6 = 22$

Expected (E_i) : $14.34 + 4.66 = 19$

No. of defectives	observed (O_i)	Expected (E_i)	$\frac{(O_i-E_i)^2}{E_i}$
0	30	30.17	0.0009
1	28	29.38	0.0657
≥ 2	22	19	0.4734

$\chi^2_{calc} = 0.0009 + 0.0657 + 0.4734$
$= 0.5403$

$df = k - p - 1 = 3 - 1 - 1 = 1$

$\chi^2_{crit} = 3.841$

$3.841 > 0.5403$

We do not reject null hypothesis

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3) $N = 150, k = 6$

$E_i = \frac{150}{6} = 25$

Sector (x)	Observed (O_i)	Expected (E_i)	$(O_i - E_i)^2 / E_i$
1	20	25	$(20-25)^2/25 = 1$
2	21	25	$(21-25)^2/25 = 0.64$
3	27	25	$(27-25)^2/25 = 0.16$
4	29	25	$(29-25)^2/25 = 0.64$
5	26	25	$(26-25)^2/25 = 0.04$
6	27	25	$(27-25)^2/25 = 0.16$

$\chi^2_{calc} = 1 + 0.64 + 0.16 + 0.64 + 0.04 + 0.16 = 2.64$

$df = 6 - 1 = 5$

$\alpha = 0.05 \qquad \chi^2_{crit} = 11.07$

$2.64 < 11.07$

we donot reject null hypothesis