- **Testing of Hypotheses concerning the Population Mean (T-Test)**

1. **Null & Alternative Hypotheses**

Null	H_0 ;	$\mu = \mu_0$	$\mu \le \mu_0$	$\mu \ge \mu_0$
Alternative	H_1 ;	$\mu \ne \mu_0$	$\mu > \mu_0$	$\mu < \mu_0$

2. **Significance Level**

α **=** 5 % / 1 % or 0.05 / 0.01

If significance level is not given then we take 5% by default.

3. **Critical Region(C.R)**

For Two Tail Test

If Alternative H_1 ; $\mu \ne \mu_0$ $\therefore d.f = n-1$

C.R = $|t| \ge t(\alpha/2, d.f)$ or $-t(\alpha/2, d.f) < t < t(\alpha/2, d.f)$

For One Tail Test

If Alternative H_1 ; $\mu > \mu_0$

C.R= $t \ge t(\alpha, d.f)$

For One Tail Test

If Alternative H_1 ; $\mu < \mu_0$

C.R= $t \le -t(\alpha, d.f)$

4. **Test Statistics**

$$\mathbf{t} = \frac{\bar{X} - \mu_0}{s/\sqrt{n}}$$

$$s = \sqrt{\frac{\Sigma(X-\bar{X})^2}{n-1}} = \sqrt{\frac{1}{n-1}\left[\sum X^2 - \frac{(\sum X)^2}{n}\right]}$$

5. **Conclusion**
   - If t-cal is greater than or equal to t-tab so rejected H_0
   - If t-cal is less than t-tab so accepted H_0

• Testing of Hypotheses concerning the difference between two Population Mean ($\bar{X}_1 - \bar{X}_2$) (T-Test)

1. **Null & Alternative Hypotheses**

Null	H_0 ;	$\mu_1 - \mu_2 = \blacktriangle_0$	$\mu_1 - \mu_2 \le \blacktriangle_0$	$\mu_1 - \mu_2 \ge \blacktriangle_0$
Alternative	H_1 ;	$\mu_1 - \mu_2 \ne \blacktriangle_0$	$\mu_1 - \mu_2 > \blacktriangle_0$	$\mu_1 - \mu_2 < \blacktriangle_0$

2. **Significance Level**

α = 5 % / 1 % or 0.05 / 0.01
If significance level is not given then we take 5% by default.

3. **Critical Region(C.R)**

For Two Tail Test

If Alternative H_1 ; $\mu_1 - \mu_2 \ne \blacktriangle_0$ $\therefore d.f = n_1 + n_2 - 2$

C.R = $|t| \ge t(\alpha/2, d.f)$ or $-t(\alpha/2, d.f) < t < t(\alpha/2, d.f)$

For One Tail Test

If Alternative H_1 ; $\mu_1 - \mu_2 > \blacktriangle_0$

C.R= $t \ge t(\alpha, d.f)$

For One Tail Test

If Alternative H_1 ; $\mu_1 - \mu_2 < \blacktriangle_0$

C.R= $t \le -t(\alpha, d.f)$

4. **Test Statistics**

$$\mathbf{t} = \frac{(\bar{X}_1 - \bar{X}_2) - \blacktriangle_0}{s_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \qquad \therefore \blacktriangle_0 = \mu_1 - \mu_2$$

$$s_p = \sqrt{\frac{1}{n_1 + n_2 - 2}\left[\left(\sum X_1^2 - \frac{(\sum X_1)^2}{n_1}\right) + \left(\sum X_2^2 - \frac{(\sum X_2)^2}{n_2}\right)\right]}$$

$$s_p = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}} \qquad s_p = \sqrt{\frac{\sum (X_1 - \bar{X}_1)^2 + \sum (X_2 - \bar{X}_2)^2}{n_1 + n_2 - 2}}$$

If $\blacktriangle_0$ is not given in question then we take $\blacktriangle_0$ =0.

5. **Conclusion**
   - If t-cal is greater than or equal to t-tab so rejected H_0
   - If t-cal is less than t-tab so accepted H_0

- **Testing of Hypotheses concerning the difference between two Population Mean ($\bar{X}_2 - \bar{X}_1$) (T-Test)**

1. **Null & Alternative Hypotheses**

Null	H_0 ;	$\mu_2 - \mu_1 = \blacktriangle_0$	$\mu_2 - \mu_1 \le \blacktriangle_0$	$\mu_2 - \mu_1 \ge \blacktriangle_0$
Alternative	H_1 ;	$\mu_2 - \mu_1 \ne \blacktriangle_0$	$\mu_2 - \mu_1 > \blacktriangle_0$	$\mu_2 - \mu_1 < \blacktriangle_0$

2. **Significance Level**

α **=** 5 % / 1 % or 0.05 / 0.01
If significance level is not given then we take 5% by default.

3. **Critical Region(C.R)**

For Two Tail Test

If Alternative H_1 ; $\mu_2 - \mu_1 \ne \blacktriangle_0$ $\therefore d.f = n_1 + n_2 - 2$

C.R = $|t| \ge t(\alpha/2, d.f)$ or $-t(\alpha/2, d.f) < t < t(\alpha/2, d.f)$

For One Tail Test

If Alternative H_1 ; $\mu_2 - \mu_1 > \blacktriangle_0$

C.R= $t \ge t(\alpha, d.f)$

For One Tail Test

If Alternative H_1 ; $\mu_2 - \mu_1 < \blacktriangle_0$

C.R= $t \le -t(\alpha, d.f)$

4. **Test Statistics**

$$\mathbf{t} = \frac{(X_2 - X_1) - \blacktriangle_0}{s_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \qquad \therefore \blacktriangle_0 = \mu_2 - \mu_1$$

$$s_p = \sqrt{\frac{1}{n_1 + n_2 - 2}\left[\left(\sum X_1{}^2 - \frac{(\sum X_1)^2}{n_1}\right) + \left(\sum X_2{}^2 - \frac{(\sum X_2)^2}{n_2}\right)\right]}$$

$$s_p = \sqrt{\frac{(n_1 - 1)\, s_1^2 + (n_2 - 1)\, s_2^2}{n_1 + n_2 - 2}} \qquad s_p = \sqrt{\frac{\sum (X_1 - \bar{X}_1)^2 + \sum (X_2 - \bar{X}_2)^2}{n_1 + n_2 - 2}}$$

If $\blacktriangle_0$ is not given in question then we take $\blacktriangle_0$ =0.

5. **Conclusion**

- If t-cal is greater than or equal to t-tab so rejected H_0
- If t-cal is less than t-tab so accepted H_0

- **Testing of Hypotheses concerning the Paired observation (d= $\bar{X}_1 - \bar{X}_2$) (T-Test)**

1. **Null & Alternative Hypotheses**

Null H_0 ; $\mu_1 - \mu_2 = \blacktriangle_0$ $\mu_1 - \mu_2 \leq \blacktriangle_0$ $\mu_1 - \mu_2 \geq \blacktriangle_0$

Alternative H_1 ; $\mu_1 - \mu_2 \neq \blacktriangle_0$ $\mu_1 - \mu_2 > \blacktriangle_0$ $\mu_1 - \mu_2 < \blacktriangle_0$

2. **Significance Level**

α = 5 % / 1 % or 0.05 / 0.01

If significance level is not given then we take 5% by default.

3. **Critical Region(C.R)**

For Two Tail Test

If Alternative H_1 ; $\mu_1 - \mu_2 \neq \blacktriangle_0$ $\therefore d.f = n-1$

C.R = $|t| \geq t(\alpha/2, d.f)$ or $-t(\alpha/2, d.f) < t < t(\alpha/2, d.f)$

For One Tail Test

If Alternative H_1 ; $\mu_1 - \mu_2 > \blacktriangle_0$

C.R= $t \geq t(\alpha, d.f)$

For One Tail Test

If Alternative H_1 ; $\mu_1 - \mu_2 < \blacktriangle_0$

C.R= $t \leq -t(\alpha, d.f)$

4. **Test Statistics**

$$\mathbf{t} = \frac{\bar{d} - \blacktriangle_0}{s_d / \sqrt{n}} \qquad \therefore \blacktriangle_0 = \mu_1 - \mu_2$$

$$\bar{d} = \sum d / n$$

$$s_d = \sqrt{\frac{1}{n-1}\left[\sum d^2 - \frac{(\sum d)^2}{n}\right]} = \sqrt{\frac{\sum (d - \bar{d})^2}{n-1}}$$

If $\blacktriangle_0$ is not given in question then we take $\blacktriangle_0$ =0.

5. **Conclusion**

- If t-cal is greater than or equal to t-tab so rejected H_0
- If t-cal is less than t-tab so accepted H_0

- **Testing of Hypotheses concerning the Paired observation (d=** $\bar{X}_2 - \bar{X}_1$ **) (T-Test)**

1. **Null & Alternative Hypotheses**

Null	H_0;	$\mu_2 - \mu_1 = \blacktriangle_0$	$\mu_2 - \mu_1 \le \blacktriangle_0$	$\mu_2 - \mu_1 \ge \blacktriangle_0$
Alternative	H_1;	$\mu_2 - \mu_1 \ne \blacktriangle_0$	$\mu_2 - \mu_1 > \blacktriangle_0$	$\mu_2 - \mu_1 < \blacktriangle_0$

2. **Significance Level**

α = 5 % / 1 % or 0.05 / 0.01
If significance level is not given then we take 5% by default.

3. **Critical Region(C.R)**

For Two Tail Test

If Alternative H_1; $\mu_2 - \mu_1 \ne \blacktriangle_0$ $\therefore d.f = n-1$

C.R = $|t| \ge t(\alpha/2, d.f)$ or $-t(\alpha/2, d.f) < t < t(\alpha/2, d.f)$

For One Tail Test

If Alternative H_1; $\mu_2 - \mu_1 > \blacktriangle_0$

C.R= $t \ge t(\alpha, d.f)$

For One Tail Test

If Alternative H_1; $\mu_2 - \mu_1 < \blacktriangle_0$

C.R= $t \le -t(\alpha, d.f)$

4. **Test Statistics**

$$\mathbf{t} = \frac{\bar{d} - \blacktriangle_0}{s_d/\sqrt{n}} \qquad \therefore \blacktriangle_0 = \mu_2 - \mu_1$$

$$\bar{d} = \sum d / n$$

$$s_d = \sqrt{\frac{1}{n-1}\left[\sum d^2 - \frac{(\sum d)^2}{n}\right]} = \sqrt{\frac{\sum (d - \bar{d})^2}{n-1}}$$

If $\blacktriangle_0$ is not given in question then we take $\blacktriangle_0$ =0.

5. Conclusion

- If t-cal is greater than or equal to t-tab so rejected H_0
- If t-cal is less than t-tab so accepted H_0

- **Testing of Hypotheses concerning the Population Correlation Coefficient when $\rho = 0$ (T-Test) or (F-Test)** $\rho = Row$

Note: - In this question we can fit T-test & F-test. Both are eligible for correlation coefficient when $\rho = 0$. By default we will fit T-test.

1. **Null & Alternative Hypotheses**

Null	H_0;	$\rho = 0$	$\rho \leq 0$	$\rho \geq 0$
Alternative	H_1;	$\rho \neq 0$	$\rho > 0$	$\rho < 0$

2. Significance Level

α **=** 5 % / 1 % or 0.05 / 0.01

If significance level is not given then we take 5% by default.

3. Critical Region(C.R)

For Two Tail Test

If Alternative H_1; $\rho \neq 0$ $\therefore d.f = n-2$

C.R = $|t| \geq t(\alpha/2, d.f)$ or $-t(\alpha/2, d.f) < t < t(\alpha/2, d.f)$

For One Tail Test

If Alternative H_1; $\rho \geq 0$

C.R= $t \geq t(\alpha, d.f)$

For One Tail Test

If Alternative H_1; $\rho \leq 0$

C.R= $t \leq -t(\alpha, d.f)$

4. Test Statistics

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

5. Conclusion

- If t-cal is greater than or equal to t-tab so rejected H_0
- If t-cal is less than t-tab so accepted H_0

- **Testing of Hypotheses about β, the Population Regression Coefficient (Y on X $\Rightarrow$ Y=a+bx) (T-Test)**

1. **Null & Alternative Hypotheses**

Null	H_0;	$\beta = \beta_0$	$\beta \le \beta_0$	$\beta \ge \beta_0$
Alternative	H_1;	$\beta \ne \beta_0$	$\beta > \beta_0$	$\beta < \beta_0$

2. **Significance Level**

α **=** 5 % / 1 % or 0.05 / 0.01
If significance level is not given then we take 5% by default.

3. **Critical Region(C.R)**

For Two Tail Test

If Alternative H_1; $\beta \ne \beta_0$ $\therefore d.f = n-2$

C.R = $|t| \ge t(\alpha/2, d.f)$ or $-t(\alpha/2, d.f) < t < t(\alpha/2, d.f)$

For One Tail Test

If Alternative H_1; $\beta > \beta_0$

C.R= $t \ge t(\alpha, d.f)$

For One Tail Test

If Alternative H_1; $\beta < \beta_0$

C.R= $t \le -t(\alpha, d.f)$

4. **Test Statistics**

$$t = \frac{b-\beta_0}{s_b}$$

$$s_b = \frac{s_{Y.X}}{\sqrt{\sum (X-\bar{X})^2}} \qquad b = \frac{n\sum XY - \left(\sum X\right)\left(\sum Y\right)}{n\sum X^2 - \left(\sum X\right)^2} = \frac{\sum XY - \left(\sum X\right)\left(\sum Y\right)/n}{\sum X^2 - \left(\sum X\right)^2/n}$$

$$s_{Y.X} = \sqrt{\frac{\sum Y^2 - a\sum Y - b\sum XY}{n-2}} = \sqrt{\frac{\sum (Y-\hat{Y})^2}{n-2}}$$

$$\sum (X-\bar{X})^2 = \sum X^2 - \left(\sum X\right)^2 \big/ n$$

5. Conclusion

- If t-cal is greater than or equal to t-tab so rejected H_0
- If t-cal is less than t-tab so accepted H_0

- **Testing of Hypotheses about β, the Population Regression Coefficient (X on Y $\Rightarrow$ X=c+dY) (T-Test)**

1. **Null & Alternative Hypotheses**

Null	H_0 ;	$\beta = \beta_0$	$\beta \le \beta_0$	$\beta \ge \beta_0$
Alternative	H_1 ;	$\beta \ne \beta_0$	$\beta > \beta_0$	$\beta < \beta_0$

2. Significance Level

α **=** 5 % / 1 % or 0.05 / 0.01
If significance level is not given then we take 5% by default.

3. Critical Region(C.R)

For Two Tail Test

If Alternative H_1 ; $\beta \ne \beta_0$ $\therefore d.f = n-2$

C.R = $|t| \ge t(\alpha/2, d.f)$ or $-t(\alpha/2, d.f) < t < t(\alpha/2, d.f)$

For One Tail Test

If Alternative H_1 ; $\beta > \beta_0$

C.R= $t \ge t(\alpha, d.f)$

For One Tail Test

If Alternative H_1 ; $\beta < \beta_0$

C.R= $t \le -t(\alpha, d.f)$

4. Test Statistics

$$\mathbf{t} = \frac{d - \beta_0}{s_d}$$

$$s_d = \frac{s_{X.Y}}{\sqrt{\sum (Y-\bar{Y})^2}} \qquad d = \frac{n\sum XY - \left(\sum X\right)\left(\sum Y\right)}{n\sum Y^2 - \left(\sum Y\right)^2} = \frac{\sum XY - \left(\sum X\right)\left(\sum Y\right)/n}{\sum Y^2 - \left(\sum Y\right)^2/n}$$

$$s_{X.Y} = \sqrt{\frac{\sum X^2 - c\sum X - d\sum XY}{n-2}} = \sqrt{\frac{\sum (X-\widehat{X})^2}{n-2}}$$

$$\sum (Y-\bar{Y})^2 = \sum Y^2 - \left(\sum Y\right)^2/n$$

5. Conclusion

- If t-cal is greater than or equal to t-tab so rejected H_0
- If t-cal is less than t-tab so accepted H_0

- **Testing of Hypotheses about α , the Intercept of Population Regression (Y on X $\Rightarrow$ Y=a+bx) (T-Test)**

1. **Null & Alternative Hypotheses**

Null	H_0;	$\alpha = \alpha_0$	$\alpha \le \alpha_0$	$\alpha \ge \alpha_0$
Alternative	H_1;	$\alpha \ne \alpha_0$	$\alpha > \alpha_0$	$\alpha < \alpha_0$

2. Significance Level

α = 5 % / 1 % or 0.05 / 0.01

If significance level is not given then we take 5% by default.

3. Critical Region(C.R)

For Two Tail Test

If Alternative H_1; $\alpha \ne \alpha_0$ $\therefore d.f = n-2$

C.R = $|t| \ge t(\alpha/2, d.f)$ or $-t(\alpha/2, d.f) < t < t(\alpha/2, d.f)$

For One Tail Test

If Alternative $H_1; \alpha > \alpha_0$

C.R= $t \ge t(\alpha, d.f)$

For One Tail Test

If Alternative $H_1; \alpha < \alpha_0$

C.R= $t \le -t(\alpha, d.f)$

4. Test Statistics

t = $\dfrac{a-\alpha_0}{s_a}$ $\therefore a = \bar{Y} - b\bar{X}$

$$s_a = s_{Y.X}\sqrt{\frac{1}{n}+\frac{X^2}{\sum(X-\bar{X})^2}}$$

$$s_{Y.X} = \sqrt{\frac{\sum Y^2 - a\sum Y - b\sum XY}{n-2}} = \sqrt{\frac{\sum(Y-\hat{Y})^2}{n-2}}$$

$$\sum(X-\bar{X})^2 = \sum X^2 - \left(\sum X\right)^2\Big/n \qquad b = \frac{n\sum XY - \left(\sum X\right)\left(\sum Y\right)}{n\sum X^2 - \left(\sum X\right)^2} = \frac{\sum XY - \left(\sum X\right)\left(\sum Y\right)/n}{\sum X^2 - \left(\sum X\right)^2\Big/n}$$

5. Conclusion

- If t-cal is greater than or equal to t-tab so rejected H_0
- If t-cal is less than t-tab so accepted H_0

- **Testing of Hypotheses about α , the Intercept of Population Regression (X on Y $\Rightarrow$ X=c+dY) (T-Test)**

1. **Null & Alternative Hypotheses**

Null	H_0;	$\alpha=\alpha_0$	$\alpha\le\alpha_0$	$\alpha\ge\alpha_0$
Alternative	H_1;	$\alpha\ne\alpha_0$	$\alpha>\alpha_0$	$\alpha<\alpha_0$

2. Significance Level

α = 5 % / 1 % or 0.05 / 0.01
If significance level is not given then we take 5% by default.

3. Critical Region(C.R)

For Two Tail Test

If Alternative H_1; $\alpha\ne\alpha_0$ $\therefore d.f = n-2$

C.R = $|t|\ge t(\alpha/2, d.f)$ or $-t(\alpha/2, d.f) < t < t(\alpha/2, d.f)$

For One Tail Test

If Alternative $H_1; \alpha>\alpha_0$

C.R= $t \ge t(\alpha, d.f)$

For One Tail Test

If Alternative $H_1; \alpha<\alpha_0$

C.R= $t \le -t(\alpha, d.f)$

4. Test Statistics

t = $\dfrac{c-\alpha_0}{s_c}$ $\qquad \therefore c = \bar{X} - b\bar{Y}$

$$s_c = s_{X.Y}\sqrt{\frac{1}{n}+\frac{Y^2}{\sum(Y-\bar{Y})^2}}$$

$$s_{X.Y} = \sqrt{\frac{\sum X^2 - c\sum X - d\sum XY}{n-2}} = \sqrt{\frac{\sum(X-\widehat{X})^2}{n-2}}$$

$$\sum(Y-\bar{Y})^2 = \sum Y^2 - \left(\sum Y\right)^2 \Big/ n \qquad d = \frac{n\sum XY - \left(\sum X\right)\left(\sum Y\right)}{n\sum Y^2 - \left(\sum Y\right)^2} = \frac{\sum XY - \left(\sum X\right)\left(\sum Y\right)\Big/ n}{\sum Y^2 - \left(\sum Y\right)^2 \Big/ n}$$

5. Conclusion

- If t-cal is greater than or equal to t-tab so rejected H_0
- If t-cal is less than t-tab so accepted H_0