- **Analysis of Variance One-way Classification or Single-Factor Experiment Equal sample size**

1. **Null & Alternative Hypotheses**

Null H_0; $\mu_1 = \mu_2 = \mu_3 \ldots\ldots\ldots\ldots\mu_k$

Alternative H_1; At least two means are not equal.

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)

C.R = $F \geq F(\alpha, V_1, V_2)$

$n = rk \qquad r = Row, k = colume$

$V_1 = k-1 \qquad V_2 = n-k \qquad V_1 \,\&\, V_2 = DegreeFreedom$

4. Test Statistics

Observation	**Treatments or Samples**			
	1	2	……. k	
1	X11	X12	X1k	
2	X21	X22	X2k	
3	X31	X32	X3k	
.	.	.	.	
.	.	.	.	
.	.	.	.	
n	Xn1	Xn2	Xnk	
T_j				$\sum T_j = T_0$ = Grand Total
T_j^2				$\sum T_j^2$ =
$\sum X_{i.j}^{\ 2}$				$\sum\sum X_{i.j}^{\ 2}$ =

i. Correction Factor = C.F = = $\dfrac{(T_0)^2}{rk}$ or $\dfrac{(T_0)^2}{n}$

ii. Total Sum of Square = T.S.S = $\sum\sum X_{i.j}^{\ 2} - C.F$

iii. Treatment(Column) Sum of Square = $\dfrac{\sum T_j^2}{r} - C.F$

iv. Error Sum of square = E.S.S = T.S.S – Treatment(Column) S.S

ANOVA Table

Source of Variation (S.O.V)	Degree Freedom (d.f)	Sum of Square (S.O.S)	Mean Square (M.S)	F-Distribution
Treatment (Sample)	k-1	Treatment(Column) S.S = $\frac{\sum T_j^2}{r} - C.F$	Treatment M.S = $s_1^2 = Treatment.(Column)S.S \big/ k-1$	$F = \frac{s_1^2}{s^2}$
Error	n-k	E.S.S = T.S.S – Treatment(Column) S.S	Error M.S = $s^2 = E.S.S \big/ n-k$	
Total	n-1	T.S.S = $\sum\sum X_{i.j}^{\ 2} - C.F$		

5. Conclusion

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

- **Analysis of Variance One-way Classification or Single-Factor Experiment Not equal sample size**

1. **Null & Alternative Hypotheses**

Null H_0; $\mu_1 = \mu_2 = \mu_3 \ldots\ldots\ldots\ldots\mu_k$

Alternative H_1; At least two means are not equal.

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)

C.R = $F \geq F(\alpha, V_1, V_2)$

$\sum n = n_1 + n_2 + n_3 \ldots\ldots k \qquad r = Row, k = colume$

$V_1 = k - 1 \qquad V_2 = \sum n - k \qquad V_1 \& V_2 = DegreeFreedom$

4. Test Statistics

Observation	**Treatments or Samples**			
	1	2	……. k	
1	X11	X12	X1k	
2	X21	X22	X2k	
3	X31	X32	X3k	
.	.	.	.	
.	.	.	.	
.	.	.	.	
n	Xn1	Xn2	Xnk	
T_j				$\sum T_j = T_0$ = Grand Total
T_j^2				$\sum T_j^2$ =
$\sum X_{i.j}^{\ 2}$				$\sum\sum X_{i.j}^{\ 2}$ =

I. Correction Factor = C.F = = $\dfrac{(T_0)^2}{\sum n}$

II. Total Sum of Square = T.S.S = $\sum\sum X_{i.j}^{\ 2} - C.F$

III. Treatment(Column) Sum of Square = $\sum \dfrac{T_j^{\ 2}}{n} - C.F$

IV. Error Sum of square = E.S.S = T.S.S – Treatment(Column) S.S

ANOVA Table

Source of Variation (S.O.V)	Degree Freedom (d.f)	Sum of Square (S.O.S)	Mean Square (M.S)	F-Distribution
Treatment (Sample)	k-1	Treatment(Column) S.S = $\sum \frac{T_j^2}{n} - C.F$	Treatment M.S = $s_1^2 = Treatment.(Column)S.S \big/ k-1$	$F = \frac{s_1^2}{s^2}$
Error	$\sum n-k$	E.S.S = T.S.S – Treatment(Column) S.S	Error M.S = $s^2 = E.S.S \big/ \sum n-k$	
Total	$\sum n-1$	T.S.S = $\sum\sum X_{i.j}{}^2 - C.F$		

5. Conclusion

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

- **Analysis of Variance Two way Classification or Two-Factor Experiment**

1. **Null & Alternative Hypotheses**

Row

Null H_0; $\mu_{B1} = \mu_{B2} = \mu_{B3} \ldots\ldots\ldots\ldots\ldots \mu_{Bk}$

Alternative H_1; At least two means are not equal.

Column

Null $H_0^{'}$; $\mu_{A1} = \mu_{A2} = \mu_{A3} \ldots\ldots\ldots\ldots\ldots \mu_{Ak}$

Alternative $H_1^{'}$ At least two means are not equal

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)

Row

C.R = $F > F(\alpha, V_1, V_2)$

$V_1 = r - 1 \qquad V_2 = (r-1)(k-1) \qquad V_1 \,\&\, V_2 = DegreeFreedom$

Column

C.R = $F > F(\alpha, V_1, V_2)$

$V_1 = k - 1 \qquad V_2 = (r-1)(k-1) \qquad V_1 \,\&\, V_2 = DegreeFreedom$

4. Test Statistics

Row / Column	A1	A2	A3	..... Ak	T_i	T_i^2	$\sum X_{i.j}^{\ 2}$
B1 B2 B3 . . . Bn	X11 X21 X31 . . . Xn1	X12 X22 X32 . . . Xn2	X13 X23 X33 . . . Xn3	X1k X2k X3k . . . Xnk			
T_j					$\sum T_j = \sum T_i = T_0$ = Grand Total	$\sum T_i^2$ =	$\sum\sum X_{i.j}^{\ 2}$
$T_j^{\ 2}$					$\sum T_j^{\ 2}$ =		
$\sum X_{i.j}^{\ 2}$					$\sum\sum X_{i.j}^{\ 2}$ =		

I. Correction Factor = C.F = = $\dfrac{(T_0)^2}{rk}$

II. Total Sum of Square = T.S.S = $\sum\sum X_{i.j}^{\ 2} - C.F$

III. Column Sum of Square =C.S.S= $\frac{\sum T_j^2}{r} - C.F$

IV. Row Sum of Square =R.S.S= $\frac{\sum T_j^2}{k} - C.F$

V. Error Sum of square = E.S.S = T.S.S - Column .S.S – Row.S.S

ANOVA Table

Source of Variation (S.O.V)	Degree Freedom (d.f)	Sum of Square (S.O.S)	Mean Square (M.S)	F-Distribution
Column	k-1	Column.S.S = $\frac{\sum T_j^2}{r} - C.F$	Column.M.S = $s_1^2 = Column.S.S \big/ k-1$	$F_{Column} = \frac{s_1^2}{s^2}$
Row	r-1	Row.S.S = $\frac{\sum T_j^2}{k} - C.F$	Row.M.S= $s_2^2 = Row.S.S \big/ r-1$	$F_{Row} = \frac{s_2^2}{s^2}$
Error	$(r-1)(k-1)$	E.S.S = T.S.S – Treatment(Column) S.S	Error M.S = $s^2 = E.S.S \big/ (r-1)(k-1)$	
Total	n-1	T.S.S = $\sum\sum X_{i.j}^{\ 2} - C.F$		

5. Conclusion

Row

- If F_{Row} -cal is greater than or equal to F_{Row} -tab so rejected H_0
- If F_{Row} -cal is less than F_{Row} -tab so accepted H_0

Column

- If F_{Column} -cal is greater than or equal to F_{Column} -tab so rejected H_0
- If F_{Column} -cal is less than F_{Column} -tab so accepted H_0