Frequently asked questions:

1. **Define the model under study for 2^3 Factorial experiment conducted under RBD**

Suppose that 2^3 Factorial experiment is conducted in a RBD with r replicates (Blocks) .

The model under study is

$$y_{(x_1,x_2,x_3)j} = \mu + \alpha(x_1,x_2,x_3) + \beta_j + \varepsilon_{(x_1,x_2,x_3)j}, \quad (x_1, x_2, x_3: 0 \text{ or } 1),\ J=1,2,\ldots r$$

Where

$y_{(x_1,x_2,x_3)j}$ - observations from j^{th} replicate receiving the treatment combination($x_1, x_2 x_3$), (x_1, x_2, x_3: 0 or 1)

μ = general effect

$\alpha(x_1, x_2, x_3)$ =effect of the treatment combination (x_1, x_2, x_3)

β_j = jth replicate effect

$\varepsilon_{(x_1,x_2,x_3)j}$ =error term

2. Give the expression for main and interaction effects in **2^3 Factorial experiment conducted under RBD**

[A] = [abc] - [bc] + [ac] – [c] + [ab] - [b] + [a] - [1]

[B] = [abc] + [bc] - [ac] – [c] + [ab] + [b] - [a] - [1]

[C] = [abc] + [bc] + [ac] + [c] - [ab] - [b] - [a] - [1]

[AB] = [abc] - [bc] - [ac] + [c] + [ab] - [b] - [a] + [1]

[AC] = [abc] - [bc] + [ac] – [c] - [ab] + [b] - [a] + [1]

[BC] = [abc] + [bc] - [ac] – [c] - [ab] - [b] + [a] + [1]

[ABC] = [abc] - [bc] - [ac] + [c] - [ab] + [b] + [a] - [1]

[abc] , [bc] , [ac] , [c] , [ab] , [b] , [a] and [1] represent the total yield of all the replicates receiving the treatment combinations **treatments (1), (*a*), (*b*), (c), (*ab*), (ac), (bc) and (abc) respectively.**

3. **State the hypothesis to be tested in 2^3 Factorial experiment conducted under RBD**

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1. H_a: A =0 (i.e.. Main effect of A is absent)

   Against the alternative

   H_a1: A #0 (i.e.. Main effect of A is present)

2. H_b: B =0 (i.e.. Main effect of B is absent)

   Against the alternative

   H_b1: B #0 (i.e.. Main effect of B is present)

3. H_c: C =0 (i.e.. Main effect of C is absent)

   Against the alternative

   H_c1: C #0 (i.e.. Main effect of C is present)

4. H_{ab}: AB =0 (i.e.. Interaction effect A B is absent)

   Against the alternative

   $H_{ab}1$: AB #0 (i.e.. Interaction effect A B is present)

5. H_{ac}: AC =0 (i.e.. Interaction effect A C is absent)

   Against the alternative

   $H_{ac}1$:AC #0 (i.e.. Interaction effect A C is present)

6. H_{bc}: BC =0 (i.e.. Interaction effect BC is absent)

   Against the alternative

   $H_{bc}1$: BC #0 (i.e.. Interaction effect BC is present)

7. H_{abc}: ABC =0 (i.e.. Three factor Interaction effect A BC is absent)

   Against the alternative

   $H_{abc}1$: A BC#0 (i.e.. Three factor Interaction effect A BC is present)

   We can also test simultaneously

4. **Write the test statistics and their distribution to test the different factorial effects in 2^3 Factorial experiment conducted under RBD**

a. to test H_a: A =0 (i.e.. Main effect of A is absent), the statistics is

$F_A = \frac{[A]^2 / 8r}{ESS / 7(r-1)}$ which follow F distribution with 1 and 37(r-1) degree of freedom

b. to test H_a: B =0 (i.e.. Main effect of B is absent), the statistics is

$F_B = \frac{[B]^2 / 8r}{ESS / 7(r-1)}$ which follow F distribution with 1 and 7(r-1) degree of freedom

c. To test H_c: C =0 (i.e.. Main effect of C is absent), the test statistics is

$F_C = \frac{[C]^2 / 8r}{ESS / 7(r-1)}$ which follow F distribution with 1 and 7(r-1) degree of freedom

d. To test H_{ab}: AB =0 (i.e.. Interaction effect A B is absent), the test statistics is

$F_{AB} = \frac{[AB]^2 / 8r}{ESS / 7(r-1)}$ which follow F distribution with 1 and 7(r-1) degree of freedom

e. To test H_{ac}: AC =0 (i.e.. Interaction effect A C is absent), the test statistics is

$F_{AC} = \frac{[AC]^2 / 8r}{ESS / 7(r-1)}$ which follow F distribution with 1 and 7(r-1) degree of freedom

f. To test H_{bc}: BC =0 (i.e.. Interaction effect BC is absent), the test statistics is

$F_{BC} = \frac{[BC]^2 / 8r}{ESS / 7(r-1)}$ which follow F distribution with 1 and 7(r-1) degree of freedom

g. To test H_{abc}: ABC =0 (i.e.. Three factor Interaction effect A BC is absent), the test statistics is

$F_{ABC} = \frac{[ABC]^2 / 8r}{ESS / 7(r-1)}$ which follow F distribution with 1 and 7(r-1) degree of freedom

Where the notations carry the usual meaning.

5. Write the Analysis of Variance Table for 2^3 Factorial expression carried out in RBD with r replicates

Source of Variation	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F ratio**	**Critical value**
Main factor A	1	SSA = $[A]^2 / 8r$	*MSSA=SSA/1*	$F_A = \frac{[A]^2 / 8r}{MESS}$	$F_{(1,\ 7(r-1))}$
Main factor B	1	SSB = $[B]^2 / 8r$	*MSSB=SSB/1*	$F_B = \frac{[B]^2 / 8r}{MESS}$	$F_{(1,\ 7(r-1))}$
Main factor C	1	SSC = $[C]^2 / 8r$	*MSSC=SSC/1*	$F_C = \frac{[C]^2 / 8r}{MESS}$	$F_{(1,\ 7(r-1))}$

Interaction AB	1	SSAB = $[AB]^2/8r$	*MSSAB= SSAB/1*	$F_{AB} = \frac{[AB]^2/8r}{MESS}$	$F_{(1,\ 7(r-1))}$
Interaction AC	1	SSAC = $[AC]^2/8r$	*MSSAC=SSAC/1*	$F_{AC} = \frac{[AC]^2/8r}{MESS}$	$F_{(1,\ 7(r-1))}$
Interaction BC	1	SSBC = $[BC]^2/8r$	*MSSBC=SSBC/1*	$F_{BC} = \frac{[BC]^2/8r}{MESS}$	$F_{(1,\ 7(r-1))}$
Interaction ABC	1	SSABC = $[ABC]^2/8r$	*MSSABC=SSABC/1*	$F_{ABC} = \frac{[ABC]^2/}{MESS}$	$F_{(1,\ 7(r-1))}$
Replicate	r-1	$BSS = \frac{\sum_{k=1}^{r} Y_{(...)k}^2}{8} - \frac{G^2}{8r}$	*MBSS= BSS/(r-1)*	*MBSS/MESS*	$F_{(r-1,\ 7(r-1))}$
Error	7(r-1)	ESS	*MESS= ESS/7(r-1)*		
Total	8r-1	$TSS = \sum_{(x1,x2,X_3)=0}^{1} \sum_{k=1}^{r} y_{(x1,x2,X_3)k}^2 - \frac{G}{8r}$			

6. Explain Yates technique to compute factorial effects in 2^3 Factorial experiment:

Step1 1: Write the treatment combination in the first column in the order, (1), (a), (b),(ab), (c), (ac), (bc) and (abc)

Step 2: Against each treatment combination, in the second column write the corresponding total yield from all the replicates.

Step 3: The entries in the third column are as follows: the first half entries are obtained by writing down in order, the pairwise sums of the values in column 2 and the second half is obtained by writing in the same order the pairwise differences of the values in the second column, the difference is taken such that the first number a pair is subtracted from the second number of the pair.

Step 4: The whole of the procedure explained in step 3 is repeated on the 3rds column and 4th column is derived.

Step 5: The procedure explained in step 3 is repeated on the 4^{th} column and 5^{th} column is derived

The first entry in the last column gives the grand total, the other entries in the last column are the total of the main effects and interaction effects corresponding to the treatment combinations denoted in the first column of the table.

The entire procedure is explained in the following table

Treatment Combination	Total yield	Column 3	Column 4	Factorial effects	Factorial effects
1	[1]	[1]+ [a]	[1]+ [a]+ [b]+ [ab]	[1]+ [a]+ [b]+ [ab]+ [c]+ [ab]+ [bc]+ [abc	Grand Total= G
a	[a]	[b]+ [ab]	[c]+ [ab]+ [bc]+ [abc	[a]- [1]+ [ab]- [b]+ [ab]-[c]+ [abc]-[bc]	[A]
b	[b]	[c]+ [ab]	[a]- [1]+ [ab]- [b]	[b]+ [ab]-{ [1]+ [a]}+ [bc]+ [abc-{[c]+ [ab]}	[B]
ab	[ab]	[bc]+ [abc	[ab]-[c]+ [abc]-[bc]	[ab]- [b]-{ [a]- [1]}+ [abc]- [bc]-{ [ab]-[c]}	[AB]
c	[c]	[a]- [1]	[b]+ [ab]-{ [1]+ [a]}	[c]+ [ab]+ [bc]+ [abc]-{ [1]+ [a]+ [b]+ [ab]}	[C]
ac	[ab]	[ab]- [b]	[bc]+ [abc-{[c]+ [ab]}	[ab]-[c]+ [abc]- [bc]-{ [a]- [1]+ [ab]- [b]}	[AC]

bc	[bc]	[ab]-[c]	[ab]- [b]-{ [a]- [1]}	[bc]+ [abc-{[c]+ [ab]}-{ [b]+ [ab]-{ [1]+ [a]}}	[BC]
abc	[abc]	[abc]-[bc]	[abc]-[bc]-{ [ab]-[c]}	[abc]-[bc]-{ [ab]-[c]}-{ [ab]-[b]-{ [a]- [1]}}	[ABC]

7. Write the expression for estimates and sum of squares of factorial effects in a 2^3 factorial experiment conducted in RBD with r replicates

Factorial effects	Best estimates	Sum of squares
[A]	[A]/4r	SSA = $[A]^2/8r$
[B]	[B]/4r	SSB = $[B]^2/8r$
[C]	[C]/4r	SSC = $[C]^2/8r$
[AB]	[AB]/4r	SSAB = $[AB]^2/8r$
[AC]	[AC]/4r	SSAC = $[AC]^2/8r$
[BC]	[BC]/4r	SSBC = $[BC]^2/8r$
[ABC]	[ABC]/4r	SSABC = $[ABC]^2/8r$

8. Given the following data compute the factorial effects using Yates` technique and give their estimates

Given a factorial experiment with three factors N, P and K each at two levels, the design and yield per plot are given below.

Replicate 1	Replicate 2	Replicate 3
np 30	1 44	pk 20
nk 32	nk 34	1 24
pk 24	p 27	npk 30
1 25	npk 36	k 32
n 46	k 32	n 28
k 39	n 30	p 26
p 32	np 30	np 36
npk 42	pk 36	nk 28

Yates table:

Treatment Combination	Total yield	Cloumn 3	Column 4	Factorial efects	Best estimates
1	93	197	378	Grand Total = 763	
n	104	181	385	[N] = 41	63.58333
P	85	197	22	[P] =-25	3.416667
np	96	188	19	[NP] =37	-2.08333
k	103	11	-16	[K] =7	3.083333
nk	94	11	-9	[NK] =-3	0.583333
pk	80	-9	0	[PK] =7	-0.25
npk	108	28	37	[NPK] =37	0.583333

9. Write the ANOVA Table for the data given in Q. No. 8

Calculations:

$$TSS = \sum_{(x1,x2,X_3)=0}^{1} \sum_{k=1}^{r} y^2_{(x1,x2,X_3)k} - \frac{G^2}{8r} =$$ 25227 – 763/24 = 25195.21

BSS = 195437/8-(763/24) = 24397.83

[Each replicate total is 270, 269, 224]

ESS = 102650.94-9740.1875-39900.06-227639.06-588.0625

=24783.56

Analysis of Variance Table.

Source of Variation	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F ratio**	**Critical value**
Main factor N	1	SSN = =70.04167	70.04	1.68	$F_{(1\ ,\ 14)=}$ 1.44
Main factor P	1	SSP = =26.04167	26.04	0.63	1.44
Main factor K	1	SSK =2.041667	2.04	0.049	1.44
Interaction NP	1	SSNP = 57.0416	57.04	1.37	1.44
Interaction NK	1	SSNK = 0.375	0.375	9.00	1.44
Interaction PK	1	SSPK = 2.041667	2.04	0.049	1.44
Interaction NPK	1	SSNPK = 57.04167	57.04	1.37	1.44
Replicate	r-1=2	$BSS = \frac{\sum_{k=1}^{r} Y_{(...)k}^2}{8} - \frac{G^2}{8r}$ =24397.83	*12198.92*	293.07	$F_{(2,14)=1.53}$
Error	7(r-1)=14	ESS=582.75	41.625		
Total	23	$TSS = \sum_{(x1,x2)=0}^{1} \sum_{k=1}^{r} y_{(x1,x2)k}^2 - \frac{G^2}{4r}$ =25195.21			

10. Complete the following ANOVA Table and interpret the table:

Source of Variation	Degree of freedom	Sum of squares	Mean sum of squares	F ratio	Critical value
Main factor N	?	70.04167	?	?	1.44
Main factor P	?	26.04167	?	?	?
Main factor K	?	2.041667	?	?	?
Interaction NP	?	57.0416	?	?	?
Interaction NK	?	0.375	?	?	?
Interaction PK	?	2.041667	?	?	?
Interaction NPK	?	57.04167	?	?	?
Replicate	3	?	?	?	1.53
Error	?	?	41.625		
Total	31	25195.21			

Ans:

Source of Variation	Degree of freedom	Sum of squares	Mean sum of squares	F ratio	Critical value
Main factor N	1	700	700	3.34	1.44
Main factor P	1	300	300	1.43	1.44
Main factor K	1	100	100	0.48	1.44
Interaction NP	1	500	500	2.38	1.44
Interaction NK	1	500	500	2.38	1.44
Interaction PK	1	300	300	1.43	1.44
Interaction NPK	1	450	450	2.15	1.44
Replicate	3	750	*250*	1.19	1.53
Error	21	4400	209.52		
Total	31	8000			

From the table observe that the main effect P, the main effect K, interaction effect PK and replication effect are significant (present)in the data and all the other factorial effects are insignificant.