Frequently asked questions:

Define the following terms:

1. **Experiment 2. Experimental design 3. Experimental units**

Experiment:

An experiment is a device to obtain answers to some scientific query. It Is a process or study that results in the collection of data. The results of experiments are not known in advance .In comparative experiment we compare the effects of two or more factors on some population characteristics, e.g. comparison of different varieties of crops, different fertilizers in a agricultural experiment ,different medicines in a medical expt.. etc.

Experimental design: Experimental design is the process of planning a study to meet the specified objectives. Planning an experiment properly is very important in order to ensure that the right type of data and a sufficient sample size and power are available to
answer the research questions of interest as clearly and efficiently as possible.

2. **Define the terms treatment and block:**

Treatment: Various objects of comparison in a comparative experiment are called treatments. For eg. In an agricultural experiment, different fertilizers or different verities of crop are treatments.

Block- Experimental units are collected together to form a relatively homogeneous group. This group is called a Block. A block is also a replicate.

3. **Discuss in brief the principles of Experimentation**:

   The experimental design involves the three basic principles viz., randomisation, replication and local control

Randomization. The first principle of an experimental design is randomization, which is a random process of assigning treatments to the experimental units. The random process implies that every possible allotment of treatments has the same probability. The purpose of randomization is to remove bias and other sources of extraneous variation, which are not controllable. Hence the treatments must be assigned at random to the experimental units

Replication. The second principle of an experimental design is replication; which is a repetition of the basic experiment. In other words, it is a complete run for all the treatments to be tested in the experiment. In all experiments, some variation is introduced because of the fact that the experimental units such as individuals or plots of land in agricultural experiments cannot be physically identical. This type of variation can be removed by using a number of experimental units. We therefore perform the experiment more than once, i.e., we repeat the basic experiment. An individual repetition is called a replicate. The number, the shape and the size of replicates depend upon the nature of the experimental material.

Local Control. The term local control, referring to the amount of balancing, blocking and grouping of the experimental units in to number of homogeneous sub plots. Balancing means that the treatments should be assigned to the experimental units in such a way that the result is a balanced arrangement of the treatments. Blocking means that like experimental units should be collected together to form a relatively homogeneous group.. The main purpose of the principle of local control is to increase the efficiency of an experimental design by decreasing the experimental error. It has been observed that all extraneous sources of variation are not removed by randomization and replication. In other words, we need to choose a design in such a manner that all extraneous sources of variation are brought under control. For this purpose, **Local Control is implemented..**

4. ***Define Completely randomised designs***

A total of *N* experimental units are available for use in the experiment. These experimental units are as homogeneous as possible; that is no source of variation can be recognized among them under any grouping or arrangement. Suppose that we have p treatments whose effect on the response has to be investigated. The experimental plan is subdivide the N plots randomly in to p parts. Such that jth part consists of nj plots. (∑nj= N). The first treatment is allocated to the first set of n1 plots, the second treatment to the second set of n2 plots,, etc. The arrangement of N plots in to groups n1, n2,… np plots is done in a completely random manner. The design so obtained is called completely randomised design.

5. **How CRD utilises the principles of randomisations and replication?**

Randomization: n_i experimental units are selected at random and i^{th} treatment is allocated to these experimental units

Replication: Each treatment appears n_i times.

6. **Derive the Least square estimators of the parameters of CRD Model**

The parameters μ and α_i are estimated by the method of least squares.

Consider error sum of squares. L = $\sum_{i=1}^{p}\sum_{j=1}^{ni}\varepsilon_{ij}^{\ 2} = \sum_{i=1}^{p}\sum_{j=1}^{ni}(y_{ij}-\mu-\alpha_i)^2$

choose the values of μ and α_i say $\hat{\mu}$ and $\hat{\alpha}_i$ that minimises L.

Which is obtained by solving p+1 simultaneous equations

$\frac{\partial L}{\partial \mu}=0$ and $\frac{\partial L}{\partial \alpha_i}=0$, i= 1,2…p_

Differentiating with respect to μ and α_i and equating to zero, we obtain p+1 equations called as normal equations as follows,

$$N\mu+\sum_{i=1}^{p} n_i\alpha_i = \sum_{i=1}^{p}\sum_{j=1}^{ni} y_{ij}$$

And

$$n_i\mu+n_i\alpha_i = \sum_{j-1}^{ni} y_{ij}$$ i= 1,2 …p

These normal equations are not linearly independent, as first equation is equal to the sum of rest p equations. Hence no unique solution exists for μ and $\alpha_{i,\ i=}$ 1,2..p. Since we have defined the treatment effects as deviations from overall mean, we add a independent constraint, $\sum_{i=1}^{p} n_i\alpha_i = 0$ and solve the simultaneous normal equations. Solving we get the solutions as

$\hat{\mu} = \bar{y}..$ and $\hat{\alpha}_i = \bar{y}_{i.} - \bar{y}..$ i=1,2..p

7. Discuss the Statistical Analysis in brief in CRD:

We investigate a formal test of the hypothesis

H_0: $\alpha_1= \alpha_2=\ldots=\alpha_p=0$

Against the alternative

H_1: at least one $\alpha_i \neq \alpha_{j,}$ for all I,j

We have assumed that the errors ϵij are normally and independently distributes with mean zero and variance σ^2. The observations y_{ij} are normally and

independently distributed with mean μ + αi and variance σ^2. Thus SST is a sum of squares in normally distributed random variables hence can be shown that SST/σ^2 is distributes as chi-square with N-1 degree freedom. Further we can shown that SSE/σ^2 is chi-square N-p degrees of freedom and that SSTR /σ^2 is chi - square variate with p-1 degrees of freedom if the null hypothesis i.e. H0 : $\alpha_i = 0$ is true. It also implies that SSTR/ σ^2 and SSE/σ^2 independently distributed chi-square random variables. Therefore if the null hypothesis is true, the ratio

$$F_\alpha = \frac{SSTR/(p-1)}{SSE/(N-p)} = \frac{MSSTR}{MSSE}$$

is distributed as F with p-1 and N-p degrees of freedom.

Equation is the test statistics for testing H_0: there is no differences in treatment means. We reject H_0 and conclude that there are differences in the treatment means if $F_\alpha > F_{\alpha,,p-1,\ N-p}$ where $F_{\alpha,\ p-1,\ N-p}$, is the table value referring to F table at α level significance corresponding to p-1and N-p degrees freedom.

8. Write the Analysis of variance Table for CRD model

Sources of variation	Degree of freedom	Sum of squares	Mean sum of squares	F-Value
Treatments	p-1	SSTR	MSSTR = SSTR/(p-1)	MSSTR/ MSSE
Error	N-p	SSE	MSSE = SSE/(p-1) (k-1)	
total	N-1	TSS		

We reject H_0 and conclude that there are differences in the treatment means if $F_0 > F_{\alpha,,p-1,\ N-p}$ Where F_0 is computed from equation 1 and $F_{\alpha,\ p-1,\ N-p}$, is the table value referring to F table at α level significance corresponding to p-1and N-p degrees freedom.

9. Write the Advantages of CRD

a) The design is very simple to implement.

b) Any number of treatments can be used with unequal replications and does not make the statistical hypothesis complicated.

c) The statistical analysis is simple. Even if some/all of the observations for any treatment is missing , the statistical analysis of the data does not become complicated

d) The design provides maximum number of degrees of freedom for the estimation of error variance. For small experiments, the precision increases with increasing number of error d.f.

10. Write the Disadvantage:

1) In most circumstances, the experimental units are not homogeneous, particularly, when a large no. of units involved. The CRD fails to take account of the variation among the experimental units as it does not use the principle of local control, This will increase the value of error variance under CRD

CRD is appropriate only if all plots are homogeneous. In reality this will never happen in field experiment, thus the CRD not recommended for field trials.