

**BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI  
(END SEMESTER EXAMINATION)**

CLASS: IMSC  
BRANCH: CQEDS

SEMESTER : IV  
SESSION : SP/2025

SUBJECT: ED223 SAMPLING TECHNIQUES AND DESIGN OF EXPERIMENTS

TIME: 3 Hours

FULL MARKS: 50

**INSTRUCTIONS:**

1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably. Notations and acronyms have their usual meanings.
4. Before attempting the question paper, be sure that you have got the correct question paper.
5. F-table will be supplemented along with this question paper.

5. Tabulated value of  $\left|Z_{\frac{\alpha}{2}}\right|$  are:  $|Z_{0.05}| = 1.645$ ,  $|Z_{0.025}| = 1.96$ ,  $|Z_{0.005}| = 2.58$

- |   |      | CO | BL |
|---|------|----|----|
| Q.1 Compare and contrast between the following with suitable examples:<br>(i) Sampling Vs Complete enumeration<br>(ii) Probability sampling Vs non-probability sampling<br>(iii) Sampling error Vs Non-sampling error<br>(iv) srswr Vs srswor   | [10] | 1  | 2  |
| Q.2(a) Suppose it is required to estimate the average value of output of a group of 6000 factories in a region so that the sample estimate lies within 10% of the true value with a confidence coefficient of 99%. Determine the minimum sample size required using srswor. The population coefficient of variation is known to be 60%. | [5]  | 2  | 3  |
| Q.2(b) In a srswr(N,n), prove that:<br>(i) sample mean is an unbiased estimator of population mean.<br>(ii) $V(\bar{y}) = \frac{\sigma^2}{n}$   | [5]  | 2  | 3  |
| Q.3(a) A sample of 5 villages are drawn out of a total of 40 villages from a tehsil with ppswr. The 1971 census population (x) is assumed as the size variable for sampling. The total of x in the tehsil is known to be 1315 (in '000). The data are given below:  | [5]  | 3  | 2  |

Village	1971 Census Population (x) ('000)	Cultivated area (y) (in '000 acres)
1	17.5	8.9
2	1.7	6.7
3	5.4	1.5
4	6.2	2.3
5	9.3	6.9

- (i) Using the above information, find the unbiased estimate of the average cultivated area in the tehsil. Estimate the standard error of the estimate of population mean. [4]  
(ii) Find the unbiased estimate of the total cultivated area in the tehsil. [1]
- Q.3(b) In an attempt to estimate the average income of a community of 200 households, the entire community is first divided into 50 clusters of size 4 (i.e. 4 households in each cluster). Then using srswor, a sample of 5 clusters are selected and each household within those clusters are observed. The following table gives the cluster wise household income ( $y_{ij}$ ) (in '000 Rs.) for the selected clusters.

Cluster no.	house1	house2	house3	house4
1	42	48	37	30
2	53	47	38	29
3	43	29	37	47
4	50	47	41	51
5	53	62	58	47

- (i) Estimate the average income for the entire community using the cluster information. Find the variance and standard error of the estimate of average income. [3]  
(ii) If the  $s^2=84.68$  (ignoring the clusters), calculate the relative efficiency of this cluster sampling (in estimating population mean) with respect to a sampling scheme using srswor (ignoring the clusters). [2]

- Q.4 The effect of four different ingredients (A,B,C,D) on the reaction time of a chemical process is being studied. An experimental design is adopted so that the batch and day effect on the reaction time can be controlled (blocked). Analyze the data from this experiment, frame appropriate hypotheses and draw conclusions (use  $\alpha = 0.05$ ). [10] 4 4

	Day			
Batch	1	2	3	4
1	A=8	B=7	C=1	D=7
2	B=11	C=2	D=7	A=3
3	C=4	D=9	A=10	B=8
4	D=6	A=4	B=10	C=5

- Q.5 An engineer is interested in the effects of cutting speed (A), tool geometry (B) and cutting angle (c) on the life (in hours) of a machine tool. Two levels of each factor are chosen, and three replicates of a  $2^3$  design are run. The experiment output is as follows: [10] 5 4

	Replicate		
Treatment combination	I	II	III
(1)	21	31	25
a	33	43	29
b	34	34	50
ab	56	47	46
c	43	45	38
ac	41	37	36
bc	61	50	54
abc	40	41	47

- (i) Estimate the average factor effects (by using the contrasts) for all main factors and their interactions. Which effects appear to be large? (ANOVA and hypothesis testing are NOT required) [8]  
(ii) If ANOVA is carried out, what will be the degrees of freedom for all the main factors, their interactions, error, and total. [2]

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