ПАМIBIA UПIVERSITY
OF SCIEПCE AПD TECHПOLOGY

FACULTY OF HEALTH AND APPLIED SCIENCES

DEPARTMENT OF MATHEMATICS AND STATISTICS

QUALIFICATION: Bachelor of science Honours in Applied Statistics	
QUALIFICATION CODE: 08BSSH	**LEVEL:** 8
COURSE CODE: SAT802S	**COURSE NAME:** SAMPLING THEORY
SESSION: NOVEMBER 2019	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

FIRST OPPORTUNITY EXAMINATION QUESTION PAPER	
EXAMINERS	DR. C.R KIKAWA
MODERATOR:	PROF SATHIYA APPUNNI

INSTRUCTIONS
1. Answer ALL the questions in the booklet provided.
2. Show clearly all the steps used in the calculations.
3. All written work must be done in blue or black ink and sketches must be done in pencil.

PERMISSIBLE MATERIALS

1. Non-programmable calculator without a cover.

THIS QUESTION PAPER CONSISTS OF 6 PAGES (including this front page)

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SAMPLING THEORY: SAT802S

EXAMINATION FIRST OPPORTUNITY, NOVEMBER 2019
Time - 3 Hrs. Attempt all Questions. Maximum marks - 100

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1. Question   (20 marks)

   (a) Discuss the following concepts as used in sampling theory, give relevant examples where applicable:

      i. Sample survey and census

                                                                               (2 marks)

      ii. Pilot survey

                                                                               (2 marks)

      iii. Elementary units or elements

                                                                               (2 marks)

   (b) Write short notes on the concepts; Probability and Non-probability Sampling.   (4 marks)

   (c) Discuss why we use or talk about sampling with replacement in sampling theory?   (5 marks)

   (d) Write short notes on the usage of auxiliary Information with a clear illustration.   (5 marks)

2. Question (20 marks)

The investigator samples 10 one-acre plots by simple random sampling and counts the number of trees (y) on each plot. She also has aerial photographs of the plantation from which she can estimate the number of trees (x) on each plot of the entire plantation. Hence, she knows $\mu_x = 19.7$ and since the two counts are approximately proportional through the origin, she uses a ratio estimate to estimate μ_y.

Table 1: To estimate the average number of trees per acre on a 1000- acre plantation

Plot	Actual no. per acre Y	Aerial estimate X	$y_i - r x_i$
1	25	23	0.5625
2	15	14	0.1250
3	22	20	0.7500
4	24	25	-2.5625
5	13	12	0.2500
6	18	18	-1.1250
7	35	30	3.1250
8	30	27	1.3125
9	10	8	1.5000
10	29	31	-3.9375
mean	22.10	20.80	-

(a) study Figures 1 and 2 and discuss the suitability of using ratio estimates. (5 marks)
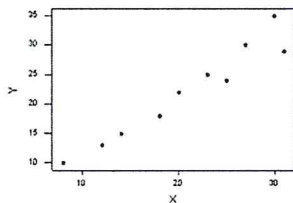

Figure 1: Scatter plot

```
The regression equation is
Y = 1.24 + 1.00 X

Predictor      Coef    SE Coef       T      P
Constant      1.239      2.007    0.62  0.554
X           1.00293    0.09094   11.03  0.000
```

Figure 2: Regression output

(b) Construct the approximate 95% confidence interval for μ_y (15 marks)

2

3. Question   (20 marks)

   (a) Discuss the concept a *simple random sample* in relation to n the sample size and N the
       population size clearly stating the selection probability of each sample.   (5 marks)

   (b) Assume you have a population of N elements and you wish to take a sample of n of these
       elements. Required to state a well known formula from the theory of permutations and
       combinations which is used to select, the number T of possible samples of n elements
       from a population of N elements.   (4 marks)

   (c) Given that a population contains 25 elements and one wishes to take a sample of 5
       elements. Use the relation stated in (b) to compute the possible samples of 5 elements
       from the population given.   (2 marks)

   (d) Explain, stepwise how to take a Simple Random Sample.   (4 marks)

   (e) As a researcher you require to use ratio estimates as an estimation method for your
       analysis, study Figures 1 and 2 in question (2) and discuss the suitability of your method. (5 marks)

3

4. Question (20 marks)

   (a) Discuss any three practical cases in which multistage sampling designs are used. (6 marks)

   (b) Two-stage sampling includes both one-stage cluster sampling and stratified random sampling as special cases.

      1. When does two-stage sampling reduce to cluster sampling?

      (4 marks)

      2. When does two-stage sampling reduce to stratified random sampling?

      (4 marks)

   (c) There are 36 departments in a small liberal arts college. One wants to estimate the average amount of money the students spent on textbooks last semester. Since the size of each department varies very much, a two-stage cluster sampling using probability proportional to size for the primary unit is carried out. The results are listed in the table below. Estimate the population mean using probability proportional to size estimator (Hansen-Hurwitz) and estimate the variance of that estimator. (6 marks)

Department	M_i	m_i	Textbook expenses in $ for last semester
1	10	4	326, 400, 423, 443
2	20	8	278, 312, 450, 350, 227, 438, 512, 403
3	30	12	512, 256, 332, 402, 512, 309, 411, 610, 422, 630, 550, 470
4	15	6	426, 312, 512, 440, 342, 533

Figure 3: Table of values

4

5. Question (20 marks)

   (a) Discuss the concept, *double sampling* clearly stating its major advantages. (6 marks)

   (b) A forest resource manager is interested in estimating the total number of dead trees in a 400 acre area of heavy infestation. She subdivides the area into 200 plots of equal sizes and uses photo counts to find the number of dead trees in 18 randomly sampled plots. She then randomly samples 8 plots out of these 18 plots and conducts a ground count on these 8 plots.

   Note: Study the tables and output given for the estimation of the total number of dead trees in the 400 acre area. So as to answer the questions that follow.

   Let x denote the number of dead trees in the plot by photo count and y the number of dead trees by ground count. The data are given as:

Plot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
x'	5	7	10	6	7	9	3	6	8	11	5	9	12	13	3	20	15	4

   Out of these 18 plots, 8 are randomly selected and a ground count is conducted.

Plot	2	3	5	6	12	15	16	17
x	7	10	7	9	9	3	20	15
y	9	13	10	11	10	4	25	17
y-rx	0.3375	0.6250	1.3375	-0.1375	-1.1375	0.2875	0.2500	-1.5625

   ```
   Variable          N        Mean      StDev
   x'               18        8.50       4.46
   x                 8       10.00       5.26
   y                 8       12.37       6.28

   Sum of x' = 153.00,  Sum of x = 80.00,
   Sum of y  =  99.00.

   Sum of squares (uncorrected) of y-rx = 6.1928
   ```

   Figure 4: Tables of values and output

   i. Compute the ratio estimate for the population total.

   (8 marks)

   ii. compute the estimated variance of the ratio estimator: use the following quantities where applicable

   $$s^2 = (st.dev \cdot y)^2 = 6.28^2$$

   $$\sum_{i=1}^{8} (y_i - r \cdot x_i)^2 = 6.1928$$

   (6 marks)

   END