Kasarani Campus
Off Thika Road
Tel. 2042692 / 3

P. O. Box
49274, 00100
NAIROBI
Westlands Campus
Pamstech House
Woodvale Grove
Tel. 4442212
Fax: 4444175

KIRIRI WOMENS' UNIVERSITY OF SCIENCE AND TECHNOLOGY
UNIVERSITY EXAMINATION, 2023/2024 ACADEMIC YEAR
FOURTH YEAR, SECOND SEMESTER EXAMINATION
FOR THE DEGREE OF BACHELOR OF SCIENCE IN MATHEMATICS
KMA 419: ANALYTICAL AND MATHEMATICAL DEMOGRAPHY

Date: 10th August, 2023
Time: 8.30am – 10.30am

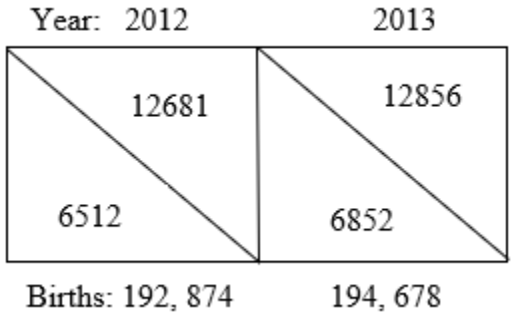
INSTRUCTIONS TO CANDIDATES
ANSWER QUESTION ONE (COMPULSORY) AND ANY OTHER TWO QUESTIONS
QUESTION ONE (30 MARKS)

a) Demographic data are important in many aspects. Explained how these data are utilized. (5 Marks)

b) The number of births that occurred to a population of size 100, 000 in the year 2022 was 792. Find the crude birth rate. (2 Marks)

c) The population growth rate is known to be proportional to the population size N.
   i) Derive the general formulae for projecting the population size at any time t given that the initial population size is N_0. (4 Marks)
   ii) Suppose that the initial population size is 1000 and the population size at year 10 is 1600. Determine the population growth rate and the time it takes for the population triple. (3 Marks)

d) Consider the Lexis diagram on infant mortality below;



Determine the infant mortality rate for the year 2013 using;
   i) Numerator separation formulae. (2 Marks)
   ii) Denominator adjustment method. (3 Marks)

e) Fill in the missing values in the following life;

Age Interval	nM_x	$_nq_x$	nlx	ndx	nLx	nTx	e_x
10-19	0.0085		89421	7288		5188228	
20-29	0.0015	0.0149			816000	4330816	

(6 Marks)

f) The wastage rate of a factory has been found to be as follows;

Year	1	2	3	4	5	6	7
Wastage Rate	0.667	0.500	0.300	0.25	0.200	0.067	1.00

Calculate the average length of service of an employee and the annual intake to maintain a work force of 2,000 persons. (5 Marks)

QUESTION TWO (20 MARKS)

a) The following data show the distribution of female population and their respective births as well are the probability of a daughter surviving to the given age group

Age Group	**Female Population**	**Total Births**	**Female births**	**Probability of Surviving**
10-14	165,000	300	180	0.95
15-19	179,000	11,000	6,500	0.87
20-24	192,000	20,000	11,500	0.85
25-29	222,000	22,000	14,700	0.83
30-34	213,000	20,000	13,000	0.81
35-39	212,000	10,000	5,500	0.77
40-44	210,000	2,000	900	0.75
45-49	200,000	500	300	0.70
Totals	**1,593,000**	**85,800**	**52, 580**	

Estimate;

i) Crude birth rate given that the population total is 2,986,875. (1 Marks)

ii) General fertility rate. (2 Marks)

iii) Total period Fertility rate. (3 Marks)

iv) General reproductive rate. (3 Marks)

v) Net reproductive rate. (3 Marks)

b)

i) Define a parity progression ratio. (2 Marks)

ii) Show that the average family size is given by;

$$b_0 + b_0 b_1 + b_0 b_1 b_2 + \ldots$$

$$Where\ b_i = \frac{number\ of\ women\ with\ at\ least\ (i+1)\ children}{Number\ of\ women\ with\ at\ least\ i\ childern}$$

(3 Marks)

iii) Let the parity table of XYZ population be given by;

Parity	0	1	2	3	4	5	6	7	8
Parity Progression Ratio	0.93	0.91	0.87	0.85	0.96	0.73	0.73	0.71	0.82

Estimate the average family size. (3 Marks)

QUESTION THREE (20 MARKS)

a) The following data relate to Age-Specific Deaths to 1960 Costa Rican Females;

Age Interval	Mid-Year Population	Deaths
<1 year	28, 661	1, 834
1-4	90, 412	695
5-9	80, 892	136
10-19	12, 782	109
20-29	91, 408	137
30-39	67, 689	168
40-49	45, 397	170
50-59	30, 958	259
60-69	16, 754	383
70-79	7, 561	410
80+	2, 048	420

i) Use the data above to construct a life table for 1960 Costa Rican females using Fergany's Method. (10 Marks)

ii) From the life table constructed above, estimate

I) The probability that a person aged between 40-49 will survive up to age group 70-79. (2 Marks)

II) The probability that a person aged 20 will die within the age interval 60-69. (3 Marks)

III) The number of years remaining to a person aged between 40-59. (1 Mark)

b) Briefly explain the uses of a life table. (4 Marks)

QUESTION FOUR (20 MARKS)

The following the population distribution by age of reference population and two study populations A and B together with their age specific death rates.

Age	Reference Population		Population A		Population B	
	Number	**ASDR**	**Number**	**ASDR**	**Number**	**ASDR**
0–4	62339	1.604132	11089	1.8036	51250	1.561
5–14	138935	0.561414	18634	0.8586	120301	0.5154
15–24	171772	0.911017	27409	2.0175	144363	0.8312
25–34	157077	1.378391	20269	1.5367	136808	1.3596
35–44	117542	1.182556	11050	1.629	106492	1.1362
45–54	97881	3.504255	6368	5.4962	91513	3.3656
55–64	74178	8.749225	3228	11.4622	70950	8.6258
65–74	36136	20.61656	1302	34.5622	34834	20.0953
75+	17327	51.30721	1104	67.9348	16223	50.1757
Totals	**873187**		**100453**		**772734**	

Actual Deaths		**392**	**3320**

a) Compute the Crude death rate of Population A and Population B. (4 Marks)

b) The computed crude death rates in agreement with the ASDRs for population A and B? If there is an anomaly in CDR and ASDR, what could be the cause? (6 Marks)

c) Using the reference population as the standard population, determine;

i) Direct standardized death rates of population A and B. (5 Marks)

ii) Indirect standardized death rates of population A and B. (5 Marks)

QUESTION FIVE (20 MARKS)

a) Suppose that a population growth rate r is proportional to the population size N. Due to the limited number of resources, the locality can only sustain K population members. Whenever population size N goes beyond K, the growth rate becomes negative. Derive a logistic model based on the information given. (7 Marks)

b) What is the advantage of logistic over exponential population growth model? (1 Marks)

c) The female population in a certain country for 2000 and 2015 are as follows;

Age group	2000	2015
0-14	61232	63476
15-29	55114	58113
30-44	48972	49816
45-59	41324	43874
60+	40628	55272

During the intervening period, the live births were distributed as follows;

15-29	39476
30-44	28271

Project the population size for the year 2030. (10 Marks)

d) Leslie Matrix population projection method in c) is based on several assumptions. Highlight any three of these assumptions. (3 Marks)