CHUKA **UNIVERSITY**

UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF DOCTOR OF PHILOSOPHY IN PLANT PATHOLOGY, MICROBIOLOGY AND BIOTECHNOLOGY, GENETICS AND PLANT BREEDING; AGRONOMY, FOOD SCIENCE AND TECHNOLOGY AND ANIMAL SCIENCES

AGRI 991/BOTA 903/MATH 900: ADVANCED BIOMETRY

STREAMS: PhD **TIME: 3 HOURS**

DAY/DATE: FRIDAY 08/08/2025 **2.30 P.M. – 5.30 P.M.**

INSTRUCTIONS

- **Answer question ONE and any other TWO questions.**
- **Use of calculators and statistical tables is allowed.**
- **Do not write anything on the question paper.**

1. A researcher conducted an experiment to investigate the effects of genotype (Factor A, 3 levels: G_1, G_2, G_3) and fungicide concentration (Factor B, 2 levels: low, high) on disease severity in plants under controlled greenhouse conditions. The genotypes were assigned to main plots and fungicide concentrations were randomly applied within subplots. The experiment was laid out as a split-plot design with 3 blocks (replicates).

(i) State an appropriate null hypothesis for the study. (2 marks)

(ii) Generate a layout for this experiment. (6 marks)

(iii) Write down the statistical model. (3 marks)

(iv) Show the possible results of the analysis. (9 marks)

2. A second-order response surface model was fitted to study the effect of processing conditions on the antioxidant activity of a functional beverage. The response variable is antioxidant activity (%), and the predictor variables are:

X_1 = Extraction temperature (°C)

X_2 = Extraction time (minutes)

X_3 = Solvent concentration (%)

The fitted model produced the following results:

Term	Estimate	Standard Error	t-Value	p-Value
Intercept	52.316	10.512	4.975	0.001
X_1	1.802	0.546	3.301	0.007
X_2	0.914	0.382	2.393	0.030
X_3	1.165	0.438	2.659	0.020
X_1X_2	-0.015	0.008	-1.875	0.084
X_1X_3	0.011	0.006	1.833	0.089
X_2X_3	0.019	0.010	1.900	0.080
X_1^2	-0.021	0.007	-3.000	0.012
X_2^2	-0.018	0.006	-3.100	0.010
X_3^2	-0.027	0.009	-3.000	0.012

(a) i. Write down the summary statistical equation. (3 marks)

ii. Interpret the results (12 marks)

b. A Poisson regression model was fitted to investigate the factors influencing the expression count of a CRISPR-edited gene in a batch of transgenic cell cultures. The outcome variable is the number of mRNA transcripts per cell (measured via single-cell RNA-seq). The experiment involved manipulating various culture conditions and genetic features.

The independent variables are:

VECTOR: Type of expression vector used (1 = strong promoter, 0 = standard promoter)

TEMP: Incubation temperature (°C)

NUTRIENT: Nutrient supplementation level (0 = low, 1 = moderate, 2 = high)

METHYL: DNA methylation level near the promoter region (quantified 0–1 scale)

The regression output is shown below:

Variable	Coefficient (β)	Standard Error	p-value
Intercept	0.732	0.273	0.008
VECTOR	1.251	0.398	0.002
TEMP	-0.054	0.022	0.018
NUTRIENT	0.468	0.181	0.010
METHYL	-1.927	0.564	0.001

Interpret the outputs. (5 marks)

3. An experiment with three levels of nitrogen was carried out over two seasons. Carry out an analysis of variance of data combined over seasons. Take $\alpha = 0.05$. (20 marks)

Season	Rep	N_0	N_{60}	N_{90}
Dry	1	14.9	16.0	16.7
	2	12.6	16.6	16.7
	3	14.5	15.7	16.8
Wet	1	15.0	16.4	16.1
	2	13.5	16.3	16.0
	3	15.4	16.6	15.9

4. A split plot experiment with three replications evaluated effects of feeding regime (main plot) and goat genotype (subplot) on average daily weight gain, giving the following results:

Feeding Regime	Replicate	SEA	SEA × Toggenburg	SEA × Boer
Grazing Only (F_1)	1	0.175	0.225	0.232
	2	0.183	0.212	0.241
	3	0.180	0.218	0.239
Grazing + Conc. (F_2)	1	0.235	0.285	0.310
	2	0.240	0.292	0.308
	3	0.238	0.288	0.312
Zero Grazing (F_3)	1	0.210	0.270	0.285
	2	0.218	0.275	0.290
	3	0.215	0.268	0.287

(a) Analyse the data to test your stated hypotheses at $\alpha = 0.05$. (17 marks)

(b) Separate the means for subplot factor using Least Significance Difference at $\alpha = 0.05$. (3 marks)

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