



# **MAASAI MARA UNIVERSITY**

**UNIVERSITY MAIN EXAMINATIONS**

**2023/2024 ACADEMIC YEAR**

**FIRST YEAR SECOND SEMESTER**

**SCHOOL OF NATURAL RESOURCE,  
ENVIRONMENTAL STUDIES & AGRICULTURE  
BACHELOR OF SCIENCE IN WILDLIFE RESOURCE  
MANAGEMENT**

**COURSE CODE: WRM 4240-1**

**COURSE TITLE: ECOLOGICAL MODELING**

**DATE: 19 TH APRIL 2024**

**TIME:0830-1030HRS**

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## **INSTRUCTIONS TO CANDIDATES**

Answer **All** the Questions in Section A and any **THREE** IN SECTION B  
*This paper consists of TWO printed pages. Please turn over*

## Section A: Answer ALL Questions (20 Marks)

### Question 1: (5 Marks)

A researcher is interested in the relationship between weight and body length for three species of rats: black rat (*Rattus rattus*), brown rat (*Rattus norvegicus*) and the Maori rat (*Rattus exulans Peale*). Let *brown* be an indicator variable for a brown rat, *black* be an indicator variable for a black rat, and *maori* be an indicator for a Maori rat.

- Write down a model where mean body weight depends linearly on body length with possibly different slopes and intercepts for each species of rat. (2 Marks)
- Write down a model where mean body weight depends linearly on body length with the same slope and intercept for all species of rat. (2 Marks)
- How many extra parameters are in model 1? (1 Mark)

### Question 2: (5 Marks)

In a study done on the effect of rainfall and sunshine on the production of a commercial crop, average rainfall throughout the year (numerical variable) and whether the crop was grown under shade or under direct sunlight (categorical variable) were the two explanatory variables and the yield of the crop was the response variable. The parallel lines model considered to explain the relationship between explanatory and response variable was

$$\mu(\text{Crop}|\text{Rainfall},\text{Shade}) = \text{Rainfall} + \text{Shade}$$

The R output for the `anova()` function is given by:

Analysis of Variance Table

Response: Yield

Variable	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rainfall	1	1161.86	1161.86	46.13	8.9e-10
Shade	1	153.24	153.24	6.08	0.015
Residuals	97	2443.20	25.19		

- In the ANOVA table, what are the values of: (4 Marks)
  - Regression Sum of Squares
  - Residual Sum of Squares
  - Mean Sum of Squares for Residual and,
  - Degrees of Freedom for Regression
- Explain the meaning of *p*-values for Rainfall and Shade on *Crop* yield (1 Mark)

### Question 3: (5 Marks)

A study was done to understand the effect of Copper and Zinc in the Protein of a given species game animal. The amount of Zinc and Copper administered to the species and the amount of Protein affected by Zinc and Copper is observed. Total number of observations was 25. A linear model without any interactions was formed to study the effect of Zinc and Copper on Protein and fitted to the observed data. The R output of the fitted model is given below.

`lm(formula = Protein ~ Copper + Zinc)`

Coefficients:

	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	195.89404	8.54780	22.917	< 2e-16 ***
Copper	-0.13529	0.07200	-1.879	0.0736 .
Zinc	-0.04469	0.00720	-6.207	3.02e-06 ***

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Residual standard error: 19.09 on 22 degrees of freedom

- What is the value of the estimated coefficient for *Copper*? (1 Mark)
- Write down the fitted equation for this data. (2 Marks)
- Based only on the p-value confidence interval, does the variable *Zinc* seem significant? Explain. (2 Marks)

#### Question 4: (5 Marks)

In a study, mammal lifespan was studied as a function of metabolism rate and body mass. The data collected had 95 observations. The R output is

Call:

`lm(formula = Life ~ Metab + Mass)`

Coefficients:

	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	8.2680063	1.0618134	7.787	9.98e-12 ***
Metab	0.0022034	0.0003475	6.341	8.38e-09 ***
Mass	-0.1058061	0.0200287	-5.283	8.49e-07 ***

- What will be the mean lifespan of species with metabolism rate 1000 and Mass 25? (2 Marks)
- Based on the regression output, what is the effect of metabolism and mass on the lifespan of a mammal. (3 Marks)

#### Section B: Answer any THREE questions (30 Marks)

##### Question 6: (10 Marks)

In a study done on the effect of pesticide spray and pruning practice on mildew disease of hops plant, data was collected on the percentage of eld affected by mildew disease (response variable), amount of pesticide sprayed

in the eld per month (numerical explanatory variable) and whether pruning of hops plant was performed or not (categorical explanatory variable).

(a) Write down the model equation representing the parallel lines model for this data. (5 marks)

(b) Write down the model equation representing the separate lines model for this data. (5 marks)

**Question 7: (10 Marks)**

A study was conducted to investigate the relationship between fuel consumption of cars used for game tour in a national park and the characteristics of the car. The response variable was fuel consumption (in kilometers per liter of petrol), and the explanatory variables were number of cylinders in the car, horsepower of the car, weight of the car and the acceleration of the car and the data set consisted of  $n = 392$  observations.

The values for ESS F-statistic for comparing between different models is given in the following tables.

Table 1: F-Statistics

Comparison with Null Model	
Model	F-Statistics
Cylinders	597
Horsepower	99
Weight	878
Acceleration	85

Table 2: F-Statistics

Comparison with <i>Cylinders</i> Model		Comparison with <i>Horsepower</i> Model	
Model	F-Statistics	Model	F-Statistics
Cylinders + Horsepower	0.03	Cylinders + Horsepower	395
Cylinders + Weight	119	Horsepower + Weight	623
Cylinders + Acceleration	1.2	Horsepower + Acceleration	53

Comparison with <i>Weight</i> Model		Comparison with <i>Acceleration</i> Model	
Model	F-Statistics	Model	F-Statistics
Cylinders + Weight	6	Cylinders + Acceleration	421
Horsepower + Weight	1.3	Horsepower + Acceleration	66
Weight + Acceleration	9	Weight + Acceleration	674

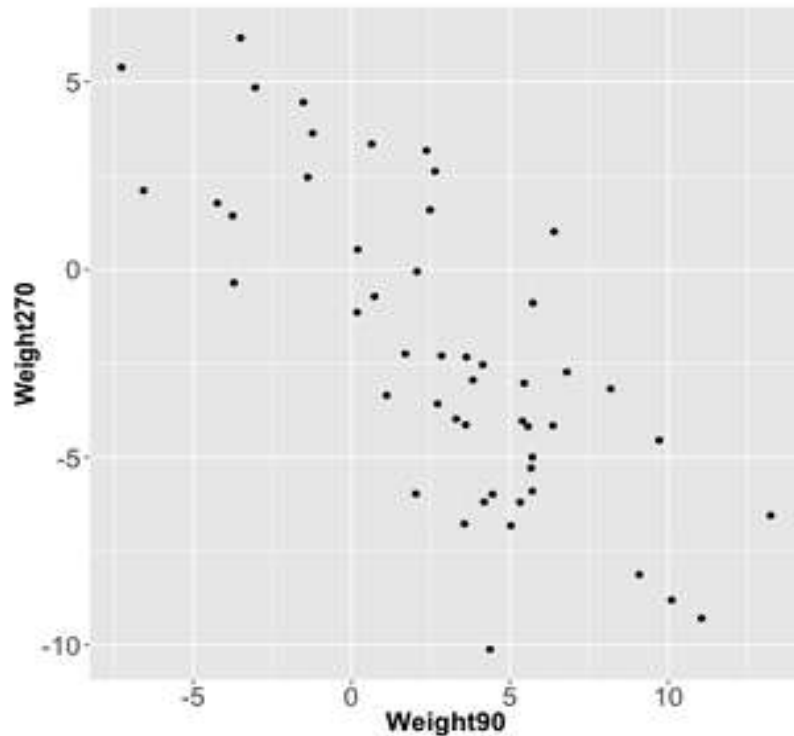
Perform Forward selection, Backward selection, and stepwise selection, to find the best model.

**Question 8: (10 Marks)**

A study was conducted on the effect of a new diet pill. The study consisted of 50 obese men. The 50 patients were divided randomly into two groups of 25

patients, and one group received the new pill and the other group received placebo pill. The pill was given every day for 90 days and then the reduction in weight was measured and then again, the reduction in weight is measured after 270 days. The goal of the study was to study the effect of the new diet pill in reducing weight both after 90 days and 270 days.

- a) By looking the scatter plot of weight reduction after 90 days and 270 days in the Figure below, do you think the strategy of separate tests for weight reduction after 90 and 270 days a good one? If not, what can be an alternate strategy? (5 marks)



- b) In the data, the pooled correlation between Weight after 90 days and weight after 270 days is 06 and the t-statistic value for testing the difference in weight after 90 days between treatment and placebo group is 2233 and the t-statistic value for testing the difference in weight after 270 days between treatment and placebo group is 13537. What will be the value of Hotellings  $T^2$  statistic? (5 marks)

**Question 9: (10 Marks)**

In a study done on the effect of pesticide spray and pruning practice on mildew disease of hops plant, data was collected on the percentage of field affected by mildew disease (response variable), amount of pesticide sprayed in the eld per month (numerical explanatory variable) and whether pruning of hops plant was performed or not (categorical explanatory variable).

- a) Write down the model equation representing the parallel lines model for this data. (4 marks)
- b) Write down the model equation representing the separate lines model for this data. (4 marks)
- c) In the model equation for separate lines, which parameter captures the difference in the change of percentage of eld affected by mildew disease for one unit change in pesticide spray when you switch pruning practice. (2 marks)

**END//**