



RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES, MIHINTALE

B.Sc. (General) Degree in Applied Biology
Second Year – Semester II Examination – April/May 2016

BIO 2114– Statistical methods in Biology II

Time: One and half (1 ½) hours

Answer all **three (3)** questions.

Illustrate your answers with labeled diagrams where appropriate.

1. a). Write down **short notes** on each of the following.
 - i. Treatment structure and design structure
 - ii). Blinding
 - b). Draw **two possible 4x4 Latin square** designs for the treatment variables named **A,B, C,** and **D** and state **four advantages** of the **Latin square** experimental design. (15 marks)
2. a) What are the **assumptions** made in when carrying out an **Analysis of variance**?
 - b) Fish in three three habitats, "**Flooded forest**", "**Mangrove habitat**" and "**Rice paddies**" were sampled using nets. Each habitat was independently sampled 5 time and the CPUE (catch per unit effort) was calculated each time. CPUE values are given below.

Flooded forest	Mangrove habitat	Rice paddies
2	3	9
4	7	8
6	6	10
8	5	12
5	9	9

- i) Name the **experimental design** used in this study.
- ii) Mention **three (03) characteristics features** of this type of experimental design.
- iii) State the appropriate **null** and **alternative hypotheses** for the study.
- iv) Conduct an appropriate **statistical test** to determine if there are significant difference in CPUE values between the three habitats at the **0.05 significance level**.
- v) Present your computed values in relavant **Analysis of Variance (ANOVA)** table

(35 marks)

3. Twenty four patients with agoraphobia are randomly assigned to one of **three drug conditions**: Paroxetine, antianxiety, and placebo. Within each drug condition, patients are randomly assigned to each of **two types of psychotherapy**: psychodynamic and cognitive. After 6 months of treatment, the severity of agoraphobia is measured as **phobia score**, for each subject (15 is the maximum possible phobia score) and recorded scores are given in table below.

Types of psychotherapy	Type of drug		
	Paroxetine	Antianxiety,	Placebo
Psychodynamic	09	06	05
	12	09	04
	11	07	02
	14	12	03
cognitive	12	12	04
	14	10	06
	15	15	02
	10	09	08

- Name the **experimental design**.
- Name the **factors** and numbers of levels in each factor in this experiment.
- What would be the **null** and **alternative hypotheses** in this research study?
- Conduct a relevant statistical test and complete the following **ANOVA** table.
- Conduct a **relevant test** to find out any **significant difference in phobia scores** at the **0.05** level of significance due to the :
 - type of drugs?**
 - types of psychotherapy?**
 - interaction between **types of drugs and psychotherapy?**
- Present computed data in appropriate ANOVA table. (50 marks)

$$SS_A = n_i \sum (\bar{X}_{i.} - \bar{\bar{X}})^2 \quad 16 \quad SS_B = n_j \sum (\bar{X}_{.j} - \bar{\bar{X}})^2$$

$$SS_{\text{error}} = \sum (X - \bar{X}_{.j})^2 \quad SS_{AB} = [n_{ij} \sum (\bar{X}_{ij} - \bar{\bar{X}})^2] - SS_A - SS_B$$

$$SS_{\text{total}} = SS_{\text{error}} + SS_A + SS_B + SS_{AB}$$

$$MS_A = SS_A/df_A \quad MS_B = SS_B/df_B \quad MS_{AB} = SS_{AB}/df_{AB} \quad MS_{\text{error}} = SS_{\text{error}}/df_{\text{error}}$$

$$F_A = MS_A / MS_{\text{error}} \quad F_B = MS_B / MS_{\text{error}} \quad F_{AB} = MS_{AB} / MS_{\text{error}}$$

$$SSTo = \sum_{j=1}^c \sum_{i=1}^r (X_{ij} - \bar{\bar{X}})^2 \quad SSTR / SSA = r \sum_{j=1}^c (\bar{X}_{.j} - \bar{\bar{X}})^2$$

$$r[(\bar{X}_1 - \bar{\bar{X}})^2 + (\bar{X}_2 - \bar{\bar{X}})^2 + \dots + (\bar{X}_c - \bar{\bar{X}})^2]$$

$$SSBL = c \sum_{i=1}^r (\bar{X}_{i.} - \bar{\bar{X}})^2 \quad r[(\bar{b}_1 - \bar{\bar{X}})^2 + (\bar{b}_2 - \bar{\bar{X}})^2 + \dots + (\bar{b}_r - \bar{\bar{X}})^2]$$

$$SSE = SSTo - SSTR - SSBL$$

$$MSA = SSA/c-1 \quad MSBL = SSBL/r-1 \quad MSE = SSE/(r-1)(c-1)$$

$$F_{\text{STAT}} = MSA/MSE \quad F_{\text{STAT}} = MSBL/MSE$$

$$SSW = \sum_i^n (X_i - \bar{X}_{\text{group}(i)})^2 \quad SSTR = \sum_{j=1}^n n_j(\bar{x}_j - \bar{\bar{x}})^2 \quad SS_{\text{Total}} = \sum_i^n (X_i - \bar{\bar{X}})^2$$

$$MS_{\text{Treat}} = SST/k-1 \quad MSE = SSE/n-k \quad F = MST/MSE$$

$$\text{Correction factor (CF)} = Y^2/r^2 \quad \text{Where } Y = \text{grand total, } r = \text{Number of rows, column or treatment}$$

$$TotalSS = \sum Y_{ij}^2 - CF \quad RowSS = \frac{\sum Row^2}{r} - CF \quad ColSS = \frac{\sum Col^2}{r} - CF \quad TrtSS = \frac{\sum Y_i^2}{r} - CF$$

$$\text{Error SS} = \text{Total SS} - \text{Row SS} - \text{Column SS} - \text{Treatment SS}$$

$$MS_{\text{row}} = SS_{\text{row}}/df_{\text{row}} \quad MS_{\text{col}} = SS_{\text{col}}/df_{\text{col}} \quad MS_{\text{treat}} = SS_{\text{tr}}/df_{\text{treat}} \quad F_{\text{treat}} = MS_{\text{Treat}}/MS_{\text{error}}$$

$$F_{\text{col}} = MS_{\text{col}}/MS_{\text{error}} \quad F_{\text{row}} = MS_{\text{row}}/MS_{\text{error}}$$

$$\text{Coefficient of correlation} = COV(X,Y)/S_X S_Y \text{ or } r = \frac{SS_{XY}}{\sqrt{(SS_{XX})(SS_{YY})}} \text{ or}$$

$$r = \frac{N \sum xy - (\sum x)(\sum y)}{\sqrt{[N \sum x^2 - (\sum x)^2][N \sum y^2 - (\sum y)^2]}}$$

$$r = \frac{N \sum xy - (\sum x)(\sum y)}{\sqrt{[N \sum x^2 - (\sum x)^2][N \sum y^2 - (\sum y)^2]}}$$

Table F The F Distribution

$\alpha = .05$										
$df_D \backslash df_N$	1	2	3	4	5	6	7	8	9	10
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5	241.9
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99
120	3.92	3.07	2.68	2.45	2.29	2.17	2.09	2.02	1.96	1.91
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83