**RAJARATA UNIVERSITY OF SRI LANKA**
**FACULTY OF APPLIED SCIENCES, MIHINTALE**

**B.Sc. (General) Degree in Applied Biology**
**Second Year – Semester II Examination – April/May 2015**

# BIO 2114 – STATISTICAL METHODS IN BIOLOGY II

**Time: 1 1/2 hours**

---

**Answer all <u>three (3)</u> questions.**

1. a) Write **short notes** on each of the following.
   i. Fixed effect and Random effect factors
   ii). Complete randomized design
   iii). Replication

   b) Identify and name the **experimental design** depicted in the figure below.

| | | | |
|---|---|---|---|
| **P** | **R** | **Q** | **S** |
| **Q** | **S** | **R** | **P** |
| **R** | **P** | **S** | **Q** |
| **S** | **Q** | **P** | **R** |

Draw another treatment combination for this design. **(15 marks)**

2. A researcher wants to investigate the effect of four newly formulated diets named **A, B, C** and **D** on the growth of guinea pigs. Each guinea pig is housed in a separate cage. A block consists of a group of four animals that experience identical environmental conditions (light, temperature, noise etc.). Each block has each of its four animals assigned at random to one of the four newly formulated diets, so that each animal in a given block is to receive a different diet. The data (weight gain in grams) are shown in the table below.

| | Diets | | | |
|---|---|---|---|---|
| Blocks | A | B | C | D |
| 1 | 7 | 5 | 9 | 5 |
| 2 | 10 | 4 | 7 | 8 |
| 3 | 9 | 3 | 8 | 6 |
| 4 | 10 | 5 | 4 | 7 |

a) Name

i) the **experimental design** used and

ii) the **dependent variable** in this study

b) Mention **two advantages** and **two disadvantages** of this type of experimental design.

c) State the appropriate **null** and **alternative hypotheses** for the study.

d) Conduct an appropriate statistical test to determine if the effect of diet and block on weight gain of guinea pigs is statistically significant at $\alpha = 0.05$.

e) Present your computed values in a Analysis of Variance (ANOVA) table. **(35 marks)**

3. Before new drugs are given to the human subjects, it is common practice to test them first on dogs or other animals. In part of one study, a new drug under investigation was given to three male and three female dogs at doses **10 mg/kg, 20 mg/kg** and **30 mg/kg**. Alkaline phosphate level (in IU/l) was measured from blood samples in order to screen for toxicity problems in dogs before starting with humans. The design of this experiment allows for the investigation of the interction of two factors: sex of the dog and dose. Data are shown in the following table.

| Dose | Male | Female |
|---|---|---|
| 10 | 5 | 7 |
| | 4 | 5 |
| | 6 | 8 |
| 20 | 4 | 6 |
| | 3 | 5 |
| | 5 | 7 |
| 30 | 9 | 10 |
| | 8 | 9 |
| | 7 | 8 |

i) Name the **experimental design**.

ii) Name the **factors** in this experiment.

iii) How many **levels** are in each factor?

iv) What would be the **null** and **alternative hypotheses** in this research study?

v) Conduct a relevant statistical test and complete the following **ANOVA** table.

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Level of dose | | 2 | | |
| Sex of dog | | | | |
| Level of dose x Sex of dog | | | | |
| Within (error) | | 12 | | |
| Total | | 17 | | |

vi) Is there any significant difference of Alkaline phosphate level in blood at the 0.05 level of significance:

a. Due to the level of **dose**?

b. Due to the **sex of dog**?

c. Due to interaction between **level of dose and sex of dog**?

**(50 marks)**

$$SS_A = n_{i.} \sum (\bar{X}_{i.} - \bar{\bar{X}}_{..})^2 \qquad SS_B = n_{.j} \sum (\bar{X}_{.j} - \bar{\bar{X}}_{..})^2$$

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

Where $n_{ij}$ and $\bar{x}_{ij}$ = $j_{th}$ observation in the $i_{th}$ treatment class

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

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

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

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

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

$$SSBL = c \sum_{i=1}^{r} (\bar{X}_{i.} - \bar{\bar{X}})^2$$

$r[(\bar{b}_1 - \bar{\bar{X}})^2 + (\bar{b}_2 - \bar{\bar{X}})^2 + \ldots\ldots + (\bar{b}_r - \bar{\bar{X}})^2]$

**SSE = SSTo - SSTr - SSBL**

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

$F_{STAT}$ = MSA/MSE $F_{STAT}$ = MSBL/MSE

*Critical values of F for the 0.05 significance level:*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 161.45 | 199.50 | 215.71 | 224.58 | 230.16 | 233.99 | 236.77 | 238.88 | 240.54 | 241.88 |
| 2 | 18.51 | 19.00 | 19.16 | 19.25 | 19.30 | 19.33 | 19.35 | 19.37 | 19.39 | 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 | 4.97 | 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 | 3.10 | 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 | 2.97 | 2.81 | 2.70 | 2.61 | 2.55 | 2.49 | 2.45 |
| 18 | 4.41 | 3.56 | 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 | 4.33 | 3.47 | 3.07 | 2.84 | 2.69 | 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 | 2.38 | 2.32 | 2.28 |
| 24 | 4.26 | 3.40 | 3.01 | 2.78 | 2.62 | 2.51 | 2.42 | 2.36 | 2.30 | 2.26 |
| 25 | 4.24 | 3.39 | 2.99 | 2.76 | 2.60 | 2.49 | 2.41 | 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 | 2.17 |
| 31 | 4.16 | 3.31 | 2.91 | 2.68 | 2.52 | 2.41 | 2.32 | 2.26 | 2.20 | 2.15 |
| 32 | 4.15 | 3.30 | 2.90 | 2.67 | 2.51 | 2.40 | 2.31 | 2.24 | 2.19 | 2.14 |
| 33 | 4.14 | 3.29 | 2.89 | 2.66 | 2.50 | 2.39 | 2.30 | 2.24 | 2.18 | 2.13 |
| 34 | 4.13 | 3.28 | 2.88 | 2.65 | 2.49 | 2.38 | 2.29 | 2.23 | 2.17 | 2.12 |
| 35 | 4.12 | 3.27 | 2.87 | 2.64 | 2.49 | 2.37 | 2.29 | 2.22 | 2.16 | 2.11 |