

Name _____

Note: There are 40 points for this exam. Number of points for each question is indicated in the left margin in square brackets. Relevant SAS outputs are given on an attached page.

1. An experiment was conducted to study the effects of a virus on corn plants. Five plants were grown in separate pots. Two comparable leaves on each plant were marked for use in the experiment. For each plant, one of the two marked leaves was randomly selected and injected with the virus and the other marked leaf was injected with a control substance. During the two weeks immediately following injections, virus-induced lesions formed on leaf surfaces. Two weeks after injections, a researcher measured the total lesion area separately for each of the two marked leaves on each of the 5 plants used in the experiment.

(a) What are the experimental units and what are the observational units for this experiment?

[2] Experimental Units:

Observational Units:

(b) What is the blocking factor(s) for this experiment?

[2]

(c) Is the experimental design a CRD (completely randomized design), RCBD (randomized complete block design), or a LS (Latin Square design)?

[1]

(d) Below is part of the ANOVA table for the analysis of the data from this study. Fill in the d.f. associated with each term.

[3]

Source	DF	Sum of Squares	Mean Square	F value	p-value
PLANT			6.32		0.076
VIRUS			8.97		0.047
Error			1.12		
C. TOTAL	9				

(e) Calculate the F statistic to test the hypothesis of no effects of virus on the lesion area of leaves.

[2]

(f) What are the degrees of freedom associated with the F distribution to test the hypothesis of virus effect?

[2]

(g) Suppose we call the design used in this study as design 1. Another design, design 2 could have been carried out as follows. Ten plants will be grown in separate pots. Five plants will be randomly selected and the virus will be injected to a leaf on these plants. For the other five plants, a leaf on each plant will be injected with a control substance. Two weeks after injections, a researcher will measure the total lesion area separately for the leaf with injection on each of the 10 plants used in the experiment. Calculate the efficiency of the design 1 relative to design 2.

[5]

(h) Are blocks a good idea in an experiment like this? Which design (design 1 or 2) would you recommend for a future study like this?

[2]

2. An experiment was conducted to study four different diets on the growth of pigs for a farm. Twelve pens each housing 3 pigs were randomly selected for this study, and three pens were randomly assigned to each of the four diets. Hence, all 3 pigs in a pen received the same diet. The weight of each pig was recorded right before the experiment started and after each diet was given for 2 weeks, and the weight gain for each pig was used as the response variable.

(a) Identify the experimental unit and observational unit in this study.

[2] Experimental Units:

Observational Units:

Below is part of the ANOVA table, including expected mean squares:

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
Diet			190.4	$\sigma^2_E + 3 \sigma^2_P + \text{stuff}$
Pen			65.05	$\sigma^2_E + 3 \sigma^2_P$
Error			1.30	σ^2_E

(b) Fill in the missing degrees of freedom (DF) values in the above table.

[3]

(c) Estimate the variance components, σ_P^2 and σ_E^2 .

[2]

(d) What is the value of the intra-class correlation between two pigs in the same pen?

[2]

3. The investigators who designed the experiment are interested in the effects of protein supplement and fiber supplement. Hence, the two factors under consideration are protein supplement (yes or no) and fiber supplement (yes or no). Depending on the addition of the corresponding supplement to the standard diet or not, the four diets described in the experiment of question 2 includes the following: NN (a standard diet without any supplements), NP (standard diet with protein supplement), FN (standard diet with fiber supplement), and FP (standard diet with both fiber supplement and protein supplement).

(a) Name the treatment design used in this study.

[2]

(b) Suppose that the investigators are interested in the following questions:

(i) Is there any difference between the standard diet with fiber supplement and the standard diet without any supplements?

(ii) Averaged over protein supplement status (yes or no), is there any effect of fiber supplement?

(iii) Does the effect of fiber supplement depend on the addition of protein supplement or not?

For each effect in parts (i)-(iii), indicate whether it is a main effect, a simple effect, or an interaction effect.

[3] (i)

(ii)

(iii)

(c) For this experiment, how many orthogonal contrasts can you get at most?

[1]

(d) Are the two contrasts (ii) and (iii) orthogonal? Give a Yes or No answer, and support your answer with appropriate calculations. Let μ_{NN} , μ_{NP} , μ_{FN} , and μ_{FP} denote the means for the diet groups NN, NP, FN, and FP, respectively.

[6]