NAME: ________________________________

(360 pts total):

Section 1 – Short answer

1. (10 pts) Derive the expression for the probability of obtaining at least one significant ($p<0.05$) result when doing k comparisons.

2. (10 pts) Define statistical power.

	Reject H_0	Do not reject H_0
H_0 true	A (Type I error)	B (Correct decision)
H_0 false	C (Correct decision)	D (Type II error)

3. (16 pts) Define Akaike's Information Criterion (AIC) and explain the logic behind it.

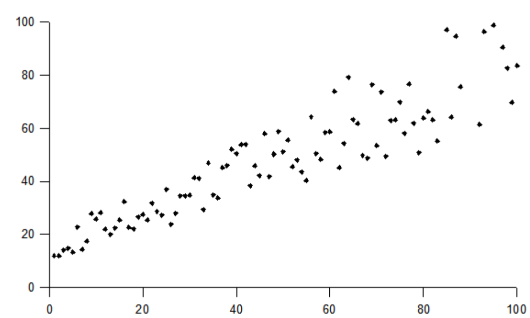
$$AIC = -2L + 2k$$

4. (10 pts) In 1-2 sentences, explain the basic idea behind robust regression. Draw a sketch if needed.

5. (10 pts) (a) What is the null hypothesis for the Kolmogorov-Smirnov test? (b) What is the test statistic for the Kolmogorov-Smirnov test?

6. (15 pts) The following data (Figure 1) violates an assumption of linear regression. What assumption is violated? How would you test whether the assumption is violated? How would you analyze the data appropriately?

Figure 1



7. (10 pts) Describe in words the difference between a “confidence interval” and a “prediction interval” when expressing uncertainty in the fit of a linear model.

8. (10 pts) What is the equation for the coefficient of determination r^2? (Define any variables used.)

9. (16 pts) An investigator wanting to study red deer foraging distances attaches telemetry collars to 20 male and 20 female adult deer and collects data for seven days in July and four days in December. Which of the variables in the study are best treated as random effects and which as fixed effects? What is the appropriate null hypothesis associated with each variable?

10. (15 pts)
    (a) What kind of response variables are modeled by logistic regression.

    (b) Write down the logistic regression equation.

(c) List three reasons why logistic regression is preferred over ordinary linear regression in cases where it is more appropriate.

11. (10 pts) Define Type I and Type II error.

	Reject H_0	Do not reject H_0
H_0 true	A (Type I error)	B (Correct decision)
H_0 false	C (Correct decision)	D (Type II error)

12. (18 points) Figure 2 illustrates the possible outcomes for a hypothetical experiment testing for the effects of substrate and predation treatment on barnacle recruitment. Each symbol represents a different treatment combination mean. Predation treatments are indicated by the x-axis label and substrate treatments are indicated by the different shades of gray (black=granite; light gray = slate; darker gray = cement). (The lines connect predation levels for each substrate, and each of the three lines represents a different substrate.) The partial error bars represent + or – 2 standard error and should be assumed equal across all three substrates. (Most of the error bars have been left off the plot for clarity. The exact size of the error bars is inconsequential to the question.)

    For each panel (A-F), decide whether the main effect of predation, the main effect of substrate, and the interaction of predation and substrate is significant ($p<0.05$) or not significant.

    Panel A
    Predation: significant / not significant (circle one)
    Substrate: significant / not significant (circle one)
    Predation x Substrate: significant / not significant (circle one)

    Panel B
    Predation: significant / not significant (circle one)
    Substrate: significant / not significant (circle one)
    Predation x Substrate: significant / not significant (circle one)

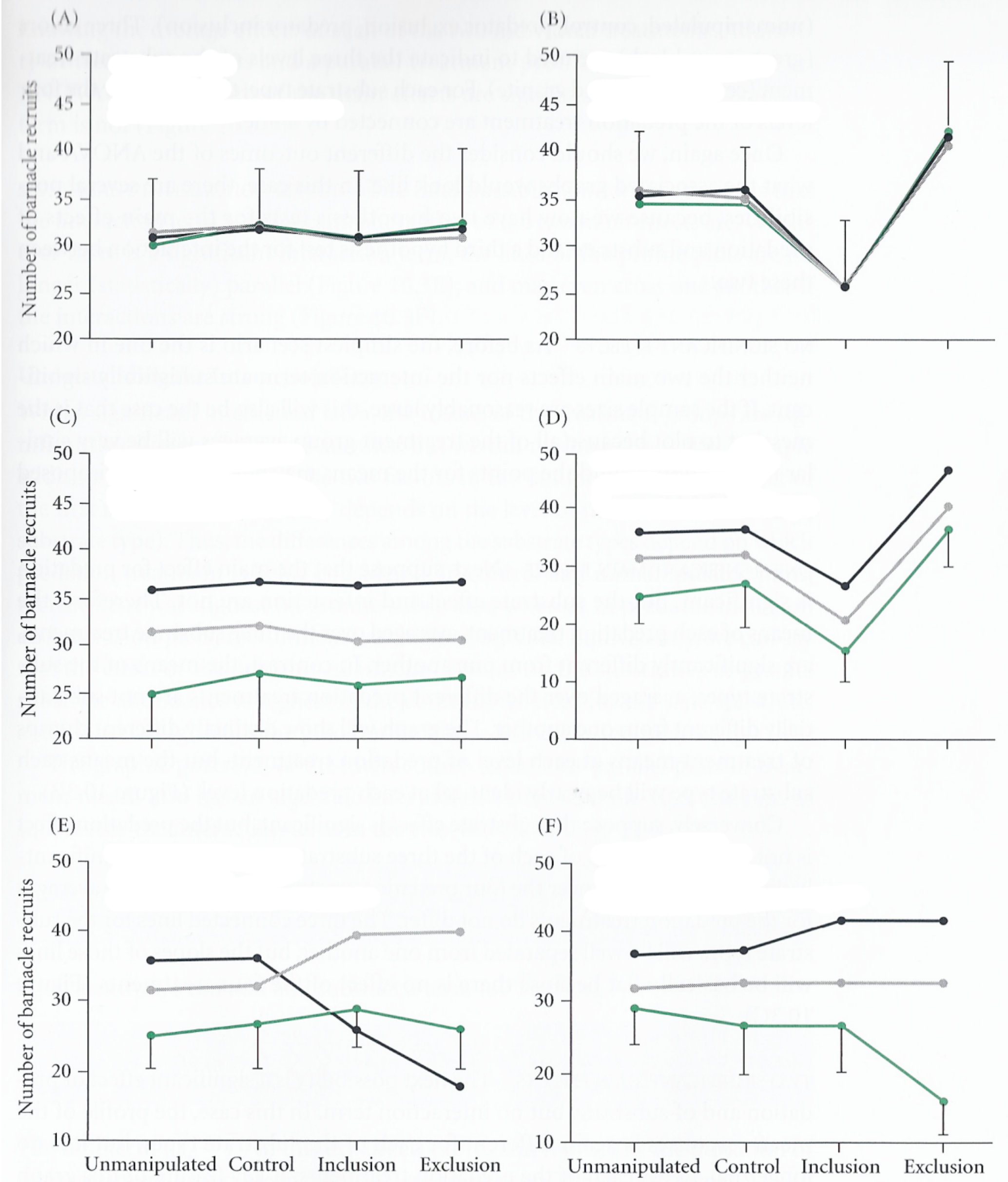
    Panel C
    Predation: significant / not significant (circle one)
    Substrate: significant / not significant (circle one)
    Predation x Substrate: significant / not significant (circle one)

    Panel D
    Predation: significant / not significant (circle one)
    Substrate: significant / not significant (circle one)
    Predation x Substrate: significant / not significant (circle one)

    Panel E
    Predation: significant / not significant (circle one)
    Substrate: significant / not significant (circle one)
    Predation x Substrate: significant / not significant (circle one)

    Panel F
    Predation: significant / not significant (circle one)
    Substrate: significant / not significant (circle one)
    Predation x Substrate: significant / not significant (circle one)

Figure 2

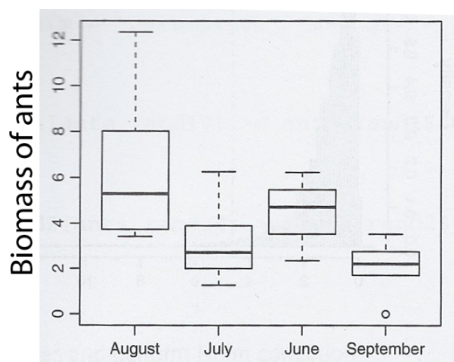


(A)
(B)
(C)
(D)
(E)
(F)
Number of barnacle recruits
Number of barnacle recruits
Number of barnacle recruits
50
45
40
35
30
25
20
0
10
Unmanipulated
Control
Inclusion
Exclusion
Unmanipulated
Control
Inclusion
Exclusion

Section 2 – Long answer

13. (75 pts) As part of a study into the diets of the eastern horned lizard (*Phrynosoma douglassi brevirostre*), Powell and Russell (1984,1985) investigated whether the consumption of ants varied over time from June to September. They measured the dry biomass of ants collected from the stomachs of 24 adult male lizards in June, July, August, and September of 1980.

Figure 3



Question 1: (10 pts) What is the null hypothesis H_0 ?

Question 2: (10 pts) What is the best parametric statistical test Powell and Russell should use to test the null hypothesis?

Question 3: (10 pts) Given that test, what is the appropriate alternative hypothesis?

Question 4: (30 pts) Work out the details of that test, including all equations or ANOVA tables as appropriate. Clearly identify the test statistic and its distribution under the null hypothesis H_0.

[LEFT BLANK FOR WORK]

Question 5: (15 pts) If Powell and Russell were concerned about inhomogeneous variances across the months, they may be skeptical that the distribution of the test statistic under the null hypothesis H_0 was valid (in other words, they may have the correct test statistic, but be getting the wrong p-value). Describe a non-parametric approach Powell and Russell may use to check the validity of the p-value obtained above.

14. (75 pts)

Consider the following toy model for the relationship between growth (response), age and food (covariates). You have 36 data points.

Model 1: $Growth \sim \beta_0 + \beta_1 Age + \beta_2 Food + error,\ error \sim N(0, \sigma^2)$ / Log-likelihood (Model 1) = -100

Model 2: $Growth \sim \beta_0 + \beta_1 Age + error,\ error \sim N(0, \sigma^2)$ / Log-likelihood (Model 2) = -99

Model 3: $Growth \sim \beta_0 + \beta_2 Food + error,\ error \sim N(0, \sigma^2)$ / Log-likelihood (Model 3) = -95

Model 4: $Growth \sim \beta_0 + error,\ error \sim N(0, \sigma^2)$ / Log-likelihood (Model 4) = -92

Question 1: Which combinations of models can be compared by a likelihood ratio test?

Question 2: What is the test statistic and distribution under the null hypothesis for the likelihood ratio test?

Question 3: Fill in the AIC model selection table below (for the last column, feel free to leave the answer as a mathematical expression)

Model	# parameters	AIC	AICc
1			
2			
3			
4			

Question 4: Discuss briefly the pros and cons of using the likelihood ratio test vs. an Information Theoretic approach such as AIC.

Section 3 – Essay (60 pts)

15. (a) Define pseudoreplication and explain why pseudoreplication is a problem for designed experiments.

(b) Name each of the experimental designs in Figure 1 (from Hurlbert 1984) and identify which are acceptable and which are unacceptable designs. For those that are unacceptable designs, explain why.

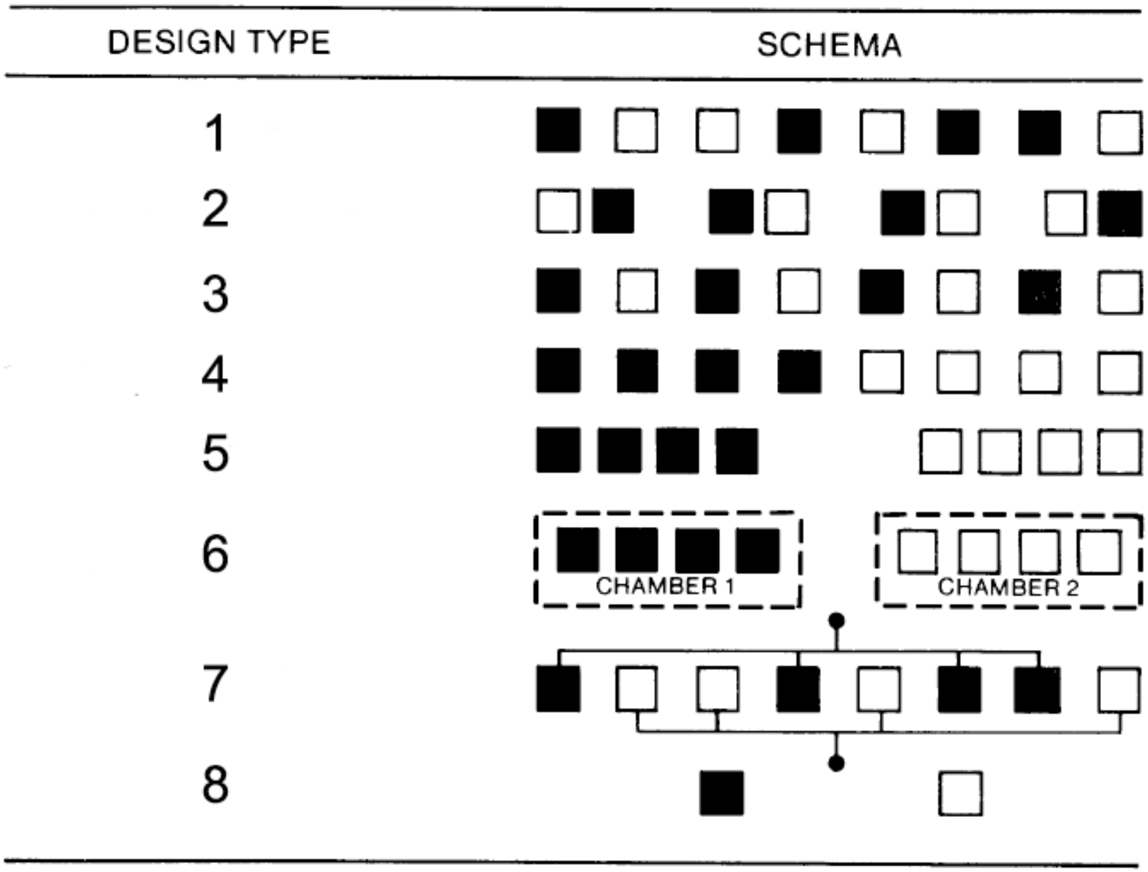


Figure 4: Schematic representation of various modes of interspersing two treatments (shaded and unshaded) in a one-dimensional arrangement. Note that in Design 7, replicates linked by solid lines share some kind of common experimental element (e.g., shared water supply, shared aeration, shared air circulation, etc.).

[LEFT BLANK FOR WORK]

(c) Describe the nature of the argument between Fisher and Gossett regarding the relative benefits of strictly random vs. systematic designs.