5. A biologist is interested in studying the effect of growth-enhancing nutrients and different salinity (salt) levels in water on the growth of shrimps. The biologist has ordered a large shipment of young tiger shrimps from a supply house for use in the study. The experiment is to be conducted in a laboratory where 10 tiger shrimps are placed randomly into each of 12 similar tanks in a controlled environment. The biologist is planning to use 3 different growth-enhancing nutrients (A, B, and C) and two different salinity levels (low and high).

   (a) List the treatments that the biologist plans to use in this experiment.

   (b) Using the treatments listed in part (a), describe a completely randomized design that will allow the biologist to compare the shrimps' growth after 3 weeks.

   (c) Give one statistical advantage to having only tiger shrimps in the experiment. Explain why this is an advantage.

   (d) Give one statistical disadvantage to having only tiger shrimps in the experiment. Explain why this is a disadvantage.

STATISTICS
SECTION II
Part B
Question 6
Spend about 25 minutes on this part of the exam.
Percent of Section II grade—25

Directions: Show all your work. Indicate clearly the methods you use, because you will be graded on the correctness of your methods as well as on the accuracy and completeness of your results and explanations.

6. A manufacturer of thermostats is concerned that the readings of its thermostats have become less reliable (more variable). In the past, the variance has been 1.52 degrees Fahrenheit (F) squared. A random sample of 10 recently manufactured thermostats was selected and placed in a room that was maintained at 68°F. The readings for those 10 thermostats are given in the table below.

Thermostat	1	2	3	4	5	6	7	8	9	10
Temperature (°F)	66.8	67.8	70.6	69.3	65.9	66.2	68.1	68.6	67.9	67.2

(a) State the null and alternative hypotheses that the manufacturer is interested in testing.

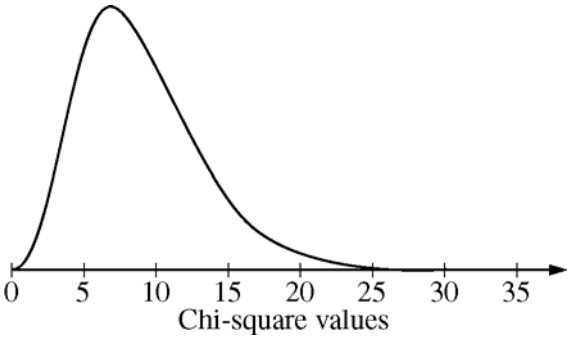
It can be shown that if the population of thermostat temperatures is normally distributed, the sampling distribution of $\frac{(n-1)s^2}{\sigma^2}$ follows a chi-square distribution with $n-1$ degrees of freedom.

(b) Calculate the value of $\frac{(n-1)s^2}{1.52}$ for these data.

(c) Assume that the population of thermostat temperatures follows a normal distribution. Use the test statistic $\frac{(n-1)s^2}{1.52}$ from part (b) and the chi-square distribution to test the hypotheses in part (a).

(d) For the test conducted in part (c), what is the smallest value of the test statistic that would have led to the rejection of the null hypothesis at the 5 percent significance level?

Mark this value of the test statistic on the graph of the chi-square distribution below. Indicate the region that contains all of the values that would have led to the rejection of the null hypothesis.



Question 5

Intent of Question

The primary goals of this question are to evaluate a student's ability to: (1) identify the treatments in a biological experiment; (2) present a completely randomized *design* to address the research question of interest; (3) describe the benefit of limiting sources of variability; and (4) describe the limitations to the scope of inference for the biologist.

Solution

Part (a):

The three different growth-enhancing nutrients (A, B, and C) and two different salinity levels (low and high) yield a total of $3 \times 2 = 6$ different treatment combinations for this experiment.

Treatment Combination	Nutrient	Salinity Level
1	A	Low
2	A	High
3	B	Low
4	B	High
5	C	Low
6	C	High

Part (b):

Since 10 tiger shrimps have already been randomly placed into each of 12 similar tanks in a controlled environment, we must randomly assign the treatment combinations to the tanks. Each treatment combination will be randomly assigned to 2 of the 12 tanks. One way to do this is to generate a random number for each tank. The treatment combinations are then assigned by sorting the random numbers from smallest to largest.

Treatment Combination	Nutrient	Salinity Level	Tanks with
1	A	Low	Smallest and second smallest random numbers
2	A	High	Third and fourth smallest random numbers
3	B	Low	Fifth and sixth smallest random numbers
4	B	High	Seventh and eighth smallest random numbers
5	C	Low	Ninth and tenth smallest random numbers
6	C	High	Next to largest and largest random numbers

Question 5 (continued)

After three weeks the weight gain (after – before) is computed for each tank, and the treatments are compared using appropriate averages.

Part (c):

Using only tiger shrimp will reduce a source of variation in the experimental units, the tanks of shrimp in this experiment. By eliminating this possible source of variation, type of shrimp, we are better able to isolate the variability due to the factors of interest to us (nutrient and salinity level). This will make it easier to identify any treatment effects that may be present.

Part (d):

Using only tiger shrimp will limit the scope of inference for the biologist. Ideally, the biologist would like to identify the treatment combination that leads to the most growth for all shrimp. However, the biologist will only be able to identify the best treatment combination for tiger shrimp because other types of shrimp may respond differently to the treatments.

Scoring

Part (a) is scored as essentially correct (E) or incorrect (I). Parts (b), (c), and (d) are scored as essentially correct (E), partially correct (P), or incorrect (I).

Part (a) is essentially correct (E) if all six treatments are correctly listed. This may be done in a 2 x 3 table or tree diagram but must clearly indicate the six treatments. A correct but incomplete listing of treatments in part (a) can be recovered in part (b) if the six treatments are clearly stated.

Listing the factors (nutrients A, B, C and salinity high, low) is incorrect and cannot be recovered in part (b).

Part (b) is essentially correct (E) if:

- each treatment combination is randomly assigned to 2 of the 12 tanks
  AND
- a correct procedure for randomization is described (so that two knowledgeable statistics users would use the same method to assign treatments to the tanks).

Part (b) is partially correct (P) if only one of these components is present. For example,

- Each treatment is randomly assigned to 2 of the 12 tanks, but the method of randomization is not fully described (i.e., just say randomly assign each treatment to 2 of the 12 tanks).
  OR
- A correct procedure for randomization of the treatments to the tanks is described, but each treatment does not necessarily appear twice.

Part (b) is incorrect (I) if there is no randomization or randomization of treatments is applied to the shrimps only (not the tanks).

Question 5 (continued)

Notes:

- If the randomization has been correctly applied to the tanks, additionally randomizing the shrimps or treatments will be regarded as extraneous.
- Because the stem indicates shrimp growth is to be compared, students are not required to identify a response variable in part (b) as was done in the model solution.

Part (c) is essentially correct (E) if

- the statistical advantage of reduced variability is identified
  AND
- an appropriate explanation that relates reduced variability to increasing the likelihood of determining differences among treatments is clearly provided.

Part (c) is partially correct (P) if only one of the two components is correct.

Part (c) is incorrect (I) if neither of the two components is present.

Notes:

- In this completely randomized design, confounding is not possible. Therefore a reference to confounding or lurking variables always incurs a penalty.

Part (d) is essentially correct (E) if

- the statistical disadvantage of limited scope of inference is identified
  AND
- an explanation that different species of shrimp may respond differently to treatments is provided.

(If the different responses to the treatments by other species of shrimp have been established in part (c), then it need not be repeated in part (d).)

Part (d) is partially correct (P) if only one of the two parts of the essentially correct response is provided.

Part (d) is incorrect (I) if neither of the two parts of the essentially correct response is provided,

4 Complete Response

3 Substantial Response

2 Developing Response

1 Minimal Response

If a response is between two scores (for example, 2½ points) use a holistic approach to determine whether to score up or down depending on the strength of the response and communication. The strength of the responses in parts (b) and (c) may be most important in making this choice.