AP Exam Practice: Sampling

1. At a certain university, students who live in the dormitories eat at a common dining hall. Recently, some students have been complaining about the quality of the food served there. The dining hall manager decided to do a survey to estimate the proportion of students living in the dormitories who think that the quality of the food should be improved. One evening, the manager asked the first 100 students entering the dining hall to answer the following question.

<table>
<thead>
<tr>
<th>Many students believe that the food in the dining hall needs improvement. Do you think that the quality of food served here needs improvement, even though that would increase the cost of the meal plan?</th>
</tr>
</thead>
<tbody>
<tr>
<td>_____ Yes _____ No _____ No opinion</td>
</tr>
</tbody>
</table>

(a) In this setting, explain how bias may have been introduced based on the way this convenience sample was selected and suggest how the sample could have been selected differently to avoid that bias.

(b) In this setting, explain how bias may have been introduced based on the way the question was worded and suggest how it could have been worded differently to avoid that bias.
2. An administrator at a large university wants to conduct a survey to estimate the proportion of students who are satisfied with the appearance of the university buildings and grounds. The administrator is considering three methods of obtaining a sample of 500 students from the 70,000 students at the university.

(a) Because of financial constraints, the first method the administrator is considering consists of taking a convenience sample to keep the expenses low. A very large number of students will attend the first football game of the season, and the first 500 students who enter the football stadium could be used as a sample. Why might such a sampling method be biased in producing an estimate of the proportion of students who are satisfied with the appearance of the buildings and grounds?

(b) Because of the large number of students at the university, the second method the administrator is considering consists of using a computer with a random number generator to select a simple random sample of 500 students from a list of 70,000 student names. Describe how to implement such a method.

(c) Because stratification can often provide a more precise estimate than a simple random sample, the third method the administrator is considering consists of selecting a stratified random sample of 500 students. The university has two campuses with male and female students at each campus. Under what circumstance(s) would stratification by campus provide a more precise estimate of the proportion of students who are satisfied with the appearance of the university buildings and grounds than stratification by gender?
3. Corn tortillas are made at a large facility that produces 100,000 tortillas per day on each of its two production lines. The distribution of the diameters of the tortillas produced on production line A is approximately normal with mean 5.9 inches, and the distribution of the diameters of the tortillas produced on production line B is approximately normal with mean 6.1 inches. The figure below shows the distributions of diameters for the two production lines.

![Diameter Distributions](image)

The tortillas produced at the factory are advertised as having a diameter of 6 inches. For the purpose of quality control, a sample of 200 tortillas is selected and the diameters are measured. From the sample of 200 tortillas, the manager of the facility wants to estimate the mean diameter, in inches, of the 200,000 tortillas produced on a given day. Two sampling methods have been proposed.

**Method 1:** Take a random sample of 200 tortillas from the 200,000 tortillas produced on a given day. Measure the diameter of each selected tortilla.

**Method 2:** Randomly select one of the two production lines on a given day. Take a random sample of 200 tortillas from the 100,000 tortillas produced by the selected production line. Measure the diameter of each selected tortilla.

(a) Will a sample obtained using Method 2 be representative of the population of all tortillas made that day, with respect to the diameters of the tortillas? Explain why or why not.
(c) Which of the two sampling methods, Method 1 or Method 2, will result in less variability in the diameters of the 200 tortillas in the sample on a given day? Explain.
4. An apartment building has nine floors and each floor has four apartments. The building owner wants to install new carpeting in eight apartments to see how well it wears before she decides whether to replace the carpet in the entire building.

The figure below shows the floors of apartments in the building with their apartment numbers. Only the nine apartments indicated with an asterisk (*) have children in the apartment.

(a) For convenience, the apartment building owner wants to use a cluster sampling method, in which the floors are clusters, to select the eight apartments. Describe a process for randomly selecting eight different apartments using this method.

(b) An alternative sampling method would be to select a stratified random sample of eight apartments, where the strata are apartments with children and apartments with no children. A stratified random sample of size eight might include two randomly selected apartments with children and six randomly selected apartments with no children. In the context of this situation, give one statistical advantage of selecting such a stratified sample as opposed to a cluster sample of eight apartments using the floors as clusters.
**ANSWERS** to AP Exam Practice: Sampling

1. **2004B #2—Dining Hall**
   a) Students who arrive early may have different opinions about food quality than other students (late-diners), thus producing a biased sample. This bias can be avoided by taking a simple random sample of all dorm residents.
   b) The phrase about the dining hall food needing improvement may lead more students to respond that the food really does need improvement. Also, the phrase indicating increased cost may also influence students to answer insincerely. Better wording: “Do you feel the quality of food needs improvement?”

2. **2013 #2—Buildings and Grounds Survey**
   a) The first 500 students who enter the football stadium were not likely to be representative of the population of all students at the university. In other words, these 500 students were likely to differ systematically from the population with regard to many variables. For example, these 500 students might have more school pride than the population of students as a whole, which might be related to their opinions about the appearance of university buildings and grounds. Perhaps their school pride is related to having more positive opinions about the appearance of university buildings and grounds, in which case the sample proportion of students who were satisfied would be biased toward overestimating the population proportion of students who were satisfied.
   b) Obtain a list of all 70,000 students at the university. Assign an identification number from 1 to 70,000 to each student. Then use a computer to generate 500 random integers between 1 and 70,000 without replacement. The students whose ID numbers correspond to those numbers were then selected for the sample.
   c) Stratifying by campus would be more advantageous than stratifying by gender provided that opinions about appearance of university buildings and grounds between the two campuses differ more than the opinions about appearance of university buildings and grounds between the two genders.

3. **2015 #6 (abc only)**
   In part (a) the response says no AND either argues that the sample will only be selected from one production line and not the entire population
   In part (b) the response chooses Method 1 AND refers to a relevant characteristic of the histogram (shape, center, or variability).
   In part (c) the response chooses Method 2 AND either justifies by stating that the sample comes from only one production line.

4. **2011 #3—Sampling Apartments**
   a) Use a random number generator to select two *different* random integers from 1 to 9. The two numbers correspond to the two floors that will be sampled, for a total of eight apartments.
   b) Using the cluster sampling method described above, it would be possible to select NO apartments with children if, say, floors 3 and 6 were picked. Since it’s reasonable to believe that carpets of apartments with children will have more wear than apartments without children, a cluster sample may not provide the owner with a good representative sample of carpet wear in this building. A stratified sample as described will allow the owner to see how well the carpet wears in both apartments with and without children.
2013 #2: Buildings and Grounds Survey (Student Samples)

Student #1:
(b) Because of the large number of students at the university, the second method the administrator is considering consists of using a computer with a random number generator to select a simple random sample of 500 students from a list of 70,000 student names. Describe how to implement such a method.

Get an alphabetical list of all the students and assign each individual a number, 1 - 70,000. Then use a random number generator to select 500 numbers, disregarding repeats, and use the people whose names correspond with the 500 numbers selected to participate in the study.

Student #2:
(a) Because of financial constraints, the first method the administrator is considering consists of taking a convenience sample to keep the expenses low. A very large number of students will attend the first football game of the season, and the first 500 students who enter the football stadium could be used as a sample. Why might such a sampling method be biased in producing an estimate of the proportion of students who are satisfied with the appearance of the buildings and grounds?

This could be biased because the students who are attending the football game are obviously very proud of their school and support their team and school. These students most likely will not have a problem with their school's appearance because they're so proud of the school itself and what it stands for.

1: Did not select random numbers “out of 70,000,” (P)
2: No mention of HOW/WHY this scenario is biased. (P)
(b) Because of the large number of students at the university, the second method the administrator is considering consists of using a computer with a random number generator to select a simple random sample of 500 students from a list of 70,000 student names. Describe how to implement such a method.

First, each student should be assigned a number that falls between 000000 and 699999. Now all 70,000 student names have a number assigned to them. Then, use a computer to generate a random digits table and pick out the first 500 numbers that fall between 000000 and 699999. When you have your 500 numbers, correspond the correct number to the correct student and you have a sample of 500 random students.

(c) Because stratification can often provide a more precise estimate than a simple random sample, the third method the administrator is considering consists of selecting a stratified random sample of 500 students. The university has two campuses with male and female students at each campus. Under what circumstance(s) would stratification by campus provide a more precise estimate of the proportion of students who are satisfied with the appearance of the university buildings and grounds than stratification by gender?

Stratification by campus would give a more precise estimate than gender because if one campus is nicer than another, that proportion will obviously be more satisfied with the appearance of the university, compared to the less appealing campus.

b) No mention of “without replacement” (P)

c) No comparison to gender option. (P)
2011 #3: Apartments (Student Samples)

Student #1, Part (a):

(a) For convenience, the apartment building owner wants to use a cluster sampling method, in which the floors are clusters, to select the eight apartments. Describe a process for randomly selecting eight different apartments using this method.

The way this method is used is a floor is first randomly selected, then an apartment in the floor is randomly selected. And you keep on doing it until the person selected eight different apartments.

Part (b):

The advantage of this that you get to see how the carpet wears with an apartment with children and in an apartment without children. If you use the cluster sampling method is you run the risk of not selecting an apartment with children for example, or maybe not maybe not enough to render it statistically significant. With the stratified random sample it's a guarantee that you are going to get enough of both.

Student #2:

Part (a):

You could randomly select 2 floors to carpet instead of randomly selecting individual rooms to carpet.

Part (b):

An advantage to this would be to see if kids play a big role in the carpets wear because if you use a cluster sample on the floors you might not get any kids located on that floor.

1a: No cluster, no method (I); b: (E)
2a: No “how” (P); b: weak, but (E)
1. Agricultural experts are trying to develop a bird deterrent to reduce costly damage to crops in the United States. An experiment is to be conducted using garlic oil to study its effectiveness as a nontoxic, environmentally safe bird repellant. The experiment will use European starlings, a bird species that causes considerable damage annually to the corn crop in the United States. Food granules made from corn are to be infused with garlic oil in each of five concentrations of garlic — 0 percent, 2 percent, 10 percent, 25 percent, and 50 percent. The researchers will determine the adverse reaction of the birds to the repellant by measuring the number of food granules consumed during a two-hour period following overnight food deprivation. There are forty birds available for the experiment, and the researchers will use eight birds for each concentration of garlic. Each bird will be kept in a separate cage and provided with the same number of food granules.

(a) For the experiment, identify

i. the treatments

ii. the experimental units

iii. the response that will be measured
2. As dogs age, diminished joint and hip health may lead to joint pain and thus reduce a dog’s activity level. Such a reduction in activity can lead to other health concerns such as weight gain and lethargy due to lack of exercise. A study is to be conducted to see which of two dietary supplements, glucosamine or chondroitin, is more effective in promoting joint and hip health and reducing the onset of canine osteoarthritis. Researchers will randomly select a total of 300 dogs from ten different large veterinary practices around the country. All of the dogs are more than 6 years old, and their owners have given consent to participate in the study. Changes in joint and hip health will be evaluated after 6 months of treatment.

(a) What would be an advantage to adding a control group in the design of this study?

(b) Assuming a control group is added to the other two groups in the study, explain how you would assign the 300 dogs to these three groups for a completely randomized design.

(c) Rather than using a completely randomized design, one group of researchers proposes blocking on clinics, and another group of researchers proposes blocking on breed of dog. How would you decide which one of these two variables to use as a blocking variable?
3. Students are designing an experiment to compare the productivity of two varieties of dwarf fruit trees. The site for the experiment is a field that is bordered by a densely forested area on the west side. The field has been divided into eight plots of approximately the same area. The students have decided that the test plots should be blocked. Four trees, each of two varieties, will be assigned at random to the four plots within each block, with one tree planted in each plot.

The two blocking schemes shown below are under consideration. For each scheme, one block is identified by the white region and the other block indicated by the grey region in the figures.

Block 1

Block 2

Key

a. Which of the blocking schemes, A or B, is better for this experiment? Explain.

b. Even though the students have decided to block, they must randomly assign the varieties of the trees to the plots within each block. What is the purpose of this randomization in the context of the experiment?
4. The dentists in a dental clinic would like to determine if there is a difference between the number of new cavities in people who eat an apple a day and in people who eat less than one apple a week. They are going to conduct a study with 50 people in each group.

Fifty clinics patients who report that they routinely eat an apple a day and 50 clinic patients who report that they eat less than one apple a week will be identified. The dentists will examine the patients and their records to determine the number of new cavities the patients have had over the past two years. They will then compare the number of new cavities in the two groups.

a. Why is this an observational study and not an experiment?

b. Explain the concept of confounding in the context of this study. Include an example of a possible confounding variable.

c. If the mean number of new cavities for those who ate an apple a day was statistically significantly smaller than the mean number of new cavities for those who ate less than one apple a week, could one conclude that the lower number of new cavities can be attributed to eating an apple a day? Explain.
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.
6. A manufacturer of boots plans to conduct an experiment to compare a new method of waterproofing to the current method. The appearance of the boots is not changed by either method. The company recruits 100 volunteers in Seattle, where it rains frequently, to wear the boots as they normally would for 6 months. At the end of the 6 months, the boots will be returned to the company to be evaluated for water damage.

(a) Describe a design for this experiment that uses the 100 volunteers. Include a few sentences on how it would be implemented.

(b) Could your design be double blind? Explain
7. When a tractor pulls a plow through an agricultural field, the energy needed to pull that plow is called the draft. The draft is affected by environmental conditions such as soil type, terrain, and moisture.

A study was conducted to determine whether a newly developed hitch would be able to reduce draft compared to the standard hitch. (A hitch is used to connect the plow to the tractor.) Two large plots of land were used in this study. It was randomly determined which plot was to be plowed using the standard hitch. As the tractor plowed that plot, a measurement device on the tractor automatically recorded the draft at 25 randomly selected points in the plot.

After the plot was plowed, the hitch was changed from the standard one to the new one, a process that takes a substantial amount of time. Then the second plot was plowed using the new hitch. Twenty-five measurements of draft were also recorded at randomly selected points in this plot.

a) What was the response variable in this study?

Identify the treatments.

What were the experimental units?

b) Given that the goal of the study is to determine whether a newly developed hitch reduces draft compared to the standard hitch, was randomization used properly in this study? Justify your answer.

c) Given that the goal of the study is to determine whether a newly developed hitch reduces draft compared to the standard hitch, was replication used properly in this study? Justify your answer.

d) Plot of land is a confounding variable in this experiment. Explain why.
1. Birds and Garlic Granules (2010 #1a)
   i. The treatments are the different concentrations of garlic in the food granules. Specifically, there are five treatments: 0 percent, 2 percent, 10 percent, 25 percent and 50 percent.
   ii. The experimental units are the birds (starlings), each placed in an individual cage.
   iii. The response is the number of food granules consumed by the bird.

2. Dogs’ Hip Health (2007 #2)
   Part (a):

   A control group gives the researchers a comparison group to be used to evaluate the effectiveness of the treatments. The control group allows the impact of the normal aging process on joint and hip health to be measured with appropriate response variables. The effects of glucosamine and chondroitin can be assessed by comparing the responses for these two treatment groups with those for the control group.

   Part (b):

   Each dog will be assigned a unique random number, 001–300, using a random number generator on a calculator, statistical software, or a random number table. The numbers will be sorted from smallest to largest. The dogs assigned the first 100 numbers in the ordered list will receive glucosamine. The dogs with the next 100 numbers in the ordered list will be assigned to the control group. Finally, the dogs with the numbers 201–300 will receive chondroitin.

   Part (c):

   The key question is which variable has the strongest association with joint and hip health. The goal of blocking is to create groups of homogeneous experimental units. It is reasonable to assume that most clinics will see all kinds and breeds of dogs so there is no reason to suspect that joint and hip health will be strongly associated with a clinic. On the other hand, different breeds of dogs tend to come in different sizes. The size of a dog is associated with joint and hip health, so it would be better to form homogeneous groups of dogs by blocking on breed.
(a) What would be an advantage to adding a control group in the design of this study?

An advantage to adding a control group to this design would be that it gives the experiment something to compare its results to, to see how much of a difference the treatments make.

(b) Assuming a control group is added to the other two groups in the study, explain how you would assign the 300 dogs to these three groups for a completely randomized design.

For every dog that is chosen roll a die. If the die is a 1 or 2 give the dog the glucosamine. If the die is a 3 or 4 give the dog the chondroitin. If the die is a 5 or 6 put the dog in the control group. This will completely randomize the design.

(c) Rather than using a completely randomized design, one group of researchers proposes blocking on clinics, and another group of researchers proposes blocking on breed of dog. How would you decide which one of these two variables to use as a blocking variable?

I would decide to use the blocking on breed of dog. The clinic the dog is in should not affect the medicine the dog is given. However, different breeds of dogs might respond to the medicines differently. Therefore, the blocking on breed of dog should be used.
(a) What would be an advantage to adding a control group in the design of this study?

The advantage to adding a control group in the design of this study would be to have something to compare the results to. This helps to reduce the effects of confounding variables. For example, the weather which can affect joint pain.

(b) Assuming a control group is added to the other two groups in the study, explain how you would assign the 300 dogs to these three groups for a completely randomized design.

To obtain a completely randomized design I would number each dog 1 to 300 and then using a random number generator I would select 100 numbers ignoring repeats the 100 dogs corresponding to those 100 numbers will be placed in the first treatment group and will receive glucosamine. I will repeat this process selecting 100 new numbers, these 100 dogs will be placed in the second treatment group and will receive chondroitin and the remaining 100 dogs will be the control group and will receive placebo.

(c) Rather than using a completely randomized design, one group of researchers proposes blocking on clinics, and another group of researchers proposes blocking on breed of dog. How would you decide which one of these two variables to use as a blocking variable?

Which ever variable has more variation should be used as a block. I think breed of dog will cause more variation in the experiment because different kinds of dogs can respond differently to the treatment, but which clinic the dogs came from probably will have less effect on the experiment.
(a) What would be an advantage to adding a control group in the design of this study?

It would be an advantage to add a control group to this study because then after 6 months, you have a group to compare with the treated dogs in the study, to see if the treatments really had an impact in promoting joint and hip health and reducing the onset of canine osteoarthritis.

(b) Assuming a control group is added to the other two groups in the study, explain how you would assign the 300 dogs to these three groups for a completely randomized design.

For a completely randomized design, I would assign each of the 300 dogs a number, 1-300, and then put all the numbers into a hat. Then draw 100 numbers out of the hat and assign them to group 1, the control group. Then pull out 100 more numbers and assign them to group 2, the glucosamine treatment. Then with the 100 left over dogs assign them to group 3, for the chondroitin treatment. That way, you will have three groups for a completely randomized design.

(c) Rather than using a completely randomized design, one group of researchers proposes blocking on clinics, and another group of researchers proposes blocking on breed of dog. How would you decide which one of these two variables to use as a blocking variable?

Rather than using a completely randomized design, I would incorporate blocking on the specific breed of dog, because the different treatments could possibly have a different effect on the different types of dogs. Therefore, I would use the blocking on breed of dog so it would eliminate any variables that could change the actual data. I would rather block on breed of dog than clinic, because breeds of dogs seem to be much more different than different clinics, therefore I would block on breeds of dogs.
3. Fruit Trees (2001 #4)

**Part (a):**

Blocking scheme A is preferable because it creates homogeneous blocks with respect to forest exposure. That is, plots in the same block have similar exposure to the forest.

**Part (b):**

Randomization of varieties of trees to the plots within each block should reduce any possible bias due to confounding variables, such as fertility or moisture, on the productivity of the two types of dwarf trees.

OR

Randomization of varieties of trees to the plots within each block should even out (or equalize) the effect of other characteristics of the plots that might be related to the productivity of the trees.

4. Dentists and Apples (1999 #3)

a. The student can appeal to any of three reasons in judging this study not an experiment:

1. there is no random assignment of subjects to treatments;
2. there are no treatments imposed;
3. existing data is being used.

b. Two variables are confounded if their effect on the number of new cavities cannot be distinguished from one another. The student must mention not only that the confounding variables may affect the outcome but that they have differential effects within the two groups. For instance: confounding would occur if patients who eat an apple a day differ from those who eat less than one apple a week on some variable that is related to dental health. In this example, diet or general level of health are examples of what might be confounding variables. For example, it is possible that people who eat an apple a day are more nutrition conscious and have a more healthy diet in general than those who eat one or fewer apples per week, and this might explain the observed difference in dental health.

**Note:**

There are many possible examples of confounding variables. Any reasonable example of a confounding variable is acceptable, as long as a good explanation is given and the connection between the confounding variable and group membership is clear. Lack of a definition here can be rectified by a response in (c) that demonstrates a clear understanding of the concept of confounding variable.

c. No, because it is not an experiment, and cause-and-effect conclusions cannot be drawn from an observational study.

OR

No, because there are possible confounding variables.
Notes:

1. In b), a good definition of confounding with a bad example should be regarded as temporarily weak. An example that does not mention group affiliation can be recovered in part c). To recover the definition of confounding in c) they must connect the term with the definition. To recover the group affiliation, they may do by example in c).

2. If the student, in attempting to discuss group differentiation, only mentions one of the groups, that is OK - we will consider the other implied. For example, it is counted correct if the student says, "The apple-eating group may be more health-conscious..." they need not explicitly deny health-consciousness to the one-apple-a-week group.

3. The constructions "Some people" and "A person in the apple-eating group may ..." are NOT enough to establish group differentiation; this construction suggests only that some subset of the group may differ from the rest of the group. This is just natural variation. The construction "A person who is an apple-eater may ..." can establish group differentiation if it is clear that this is describing a representative member of the group.

4. Mentioning initial non-equivalence of groups without tying that non-equivalence to the outcome is not correct. Mentioning concepts such as self-reporting bias, social desirability, etc. may constitute measurement error in the study but is not confounding.

5. In (c), appealing to the definition of confounding variables in (b) would get a "correct" for (c) if the definition in (b) is correct. If the definition in (b) is weak, that appeal alone would not get credit.

6. If the definition in (b) is "there are other variables that affect the outcome measure, such as age, health, etc," this is not regarded as a correct definition for purposes of appealing to the definition from (c). For purposes of reading part (b), this definition would be regarded as weak.

7. If in (c), they give an example which is the equivalent of confounding, and refer to this as confounding, they would get credit for (b).

5. Shrimp (2006 #5)

Part (a):

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

<table>
<thead>
<tr>
<th>Treatment Combination</th>
<th>Nutrient</th>
<th>Salinity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>Low</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>Low</td>
</tr>
<tr>
<td>4</td>
<td>B</td>
<td>High</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
<td>Low</td>
</tr>
<tr>
<td>6</td>
<td>C</td>
<td>High</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Treatment Combination</th>
<th>Nutrient</th>
<th>Salinity Level</th>
<th>Tanks with</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>Low</td>
<td>Smallest and second smallest random numbers</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
<td>High</td>
<td>Third and fourth smallest random numbers</td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>Low</td>
<td>Fifth and sixth smallest random numbers</td>
</tr>
<tr>
<td>4</td>
<td>B</td>
<td>High</td>
<td>Seventh and eighth smallest random numbers</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
<td>Low</td>
<td>Ninth and tenth smallest random numbers</td>
</tr>
<tr>
<td>6</td>
<td>C</td>
<td>High</td>
<td>Next to largest and largest random numbers</td>
</tr>
</tbody>
</table>

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.

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

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.
6. Boots (2002 #2)

**Part (a):**

A **paired design** is used in which each subject receives a pair of boots where one boot is treated with the new method and the other with the current method.

Subjects should be randomly assigned to one of two groups. Group 1 would have the new method applied to the right boot; group 2 would have the new method applied to the left boot. 

**OR**

For each subject, whether the new method is applied to the right or left boot is determined at random.

**OR**

A **crossover design** is used in which each subject receives a pair of boots, both of which were treated with one treatment. The boots are used for three months and then exchanged for a second pair of boots, both of which were treated with the other treatment. These boots are then used for the next three months. Subjects should be randomly assigned to one of two groups. One group receives boots with the new treatment first and the other group receives boots with the current method first.

**NOTE:** Additional appropriate blocking schemes are considered extraneous.

**Part (b):**

The design could be double blind, as long as both the subjects and the person evaluating the boots for water damage do not know which boots were treated with the new method and which were treated with the current method.

**NOTE:** If the student does something unexpected in part (a) and gives a design that actually cannot be double blind, then part (b) could be considered correct provided the response explains why the design could not be double blind.

7. 2006B, #5

**Part (a):**

The response variable was the amount of draft. The two treatments were the standard hitch and the new hitch. The experimental units were the two large plots of land.

**Part (b):**

Yes, the two hitches (treatments) were randomly assigned to the two plots (experimental units).

**Part (c):**

No, each treatment (type of hitch) was applied to only one experimental unit (plot of land). Replication is used to repeat the treatments on different experimental units so general patterns can be observed. There is no replication in this study.

**Part (d):**

Although 25 measurements were taken at different locations in the two plots, each hitch was used in one plot (experimental unit) only. Thus, if a difference in the draft is observed we will not know whether the difference is due to the hitch or the plot. In statistical language, the treatments (hitches) are confounded with the plots.