R4.7 **Ugly fries** Few people want to eat discolored french fries. Potatoes are kept refrigerated before being cut for french fries to prevent spoiling and preserve flavor. But immediate processing of cold potatoes causes discoloring due to complex chemical reactions. The potatoes must therefore be brought to room temperature before processing. Researchers want to design an experiment in which tasters will rate the color and flavor of french fries prepared from several groups of potatoes. The potatoes will be freshly picked or stored for a month at room temperature or stored for a month refrigerated. They will then be sliced and cooked either immediately or after an hour at room temperature.

(a) Identify the experimental units, the explanatory and response variables, and the treatments.

(b) The researchers plan to use a completely randomized design. Describe how they should assign treatments to the experimental units if there are 300 potatoes available for the experiment.

(c) The researchers decided to do a follow-up experiment using sweet potatoes as well as regular potatoes. Describe how they should change the design of the experiment to account for the addition of sweet potatoes.

R4.8 **Don't catch a cold!** A recent study of 1000 students at the University of Michigan investigated how to prevent catching the common cold. The students were randomly assigned to three different cold prevention methods for 6 weeks. Some wore masks, some wore masks and used hand sanitizer, and others took no precautions. The two groups who used masks reported 10–50% fewer cold symptoms than those who did not wear a mask.[62]

(a) Does this study allow for inference about a population? Explain.

(b) Does this study allow for inference about cause and effect? Explain.

R4.9 **An herb for depression?** Does the herb Saint-John's-wort relieve major depression? Here is an excerpt from the report of a study of this issue: "Design: Randomized, Double-Blind, Placebo-Controlled Clinical Trial."[63] The study concluded that the difference in effectiveness of Saint-John's-wort and a placebo was not statistically significant.

(a) How did the design of this experiment account for the placebo effect?

(b) Explain the purpose of the random assignment.

(c) Why is a double-blind design a good idea in this setting?

(d) Explain what "not statistically significant" means in this context.

R4.10 **How long did I work?** A psychologist wants to know if the difficulty of a task influences our estimate of how long we spend working at it. She designs two sets of mazes that subjects can work through on a computer. One set has easy mazes and the other has difficult mazes. Subjects work until told to stop (after 6 minutes, but subjects do not know this). They are then asked to estimate how long they worked. The psychologist has 30 students available to serve as subjects.

(a) Describe an experiment using a completely randomized design to learn the effect of difficulty on estimated time.

(b) Describe a matched pairs experimental design using the same 30 subjects.

(c) Which design would be more likely to detect a difference in the effects of the treatments? Explain.

R4.11* **Deceiving subjects** Students sign up to be subjects in a psychology experiment. When they arrive, they are told that interviews are running late and are taken to a waiting room. The experimenters then stage a theft of a valuable object left in the waiting room. Some subjects are alone with the thief, and others are in pairs—these are the treatments being compared. Will the subject report the theft?

(a) The students had agreed to take part in an unspecified study, and the true nature of the experiment is explained to them afterward. Does this meet the requirement of informed consent? Explain.

(b) What two other ethical principles should be followed in this study?

*This is an important topic, but it is not required for the AP® Statistics exam.

Chapter 4 AP® Statistics Practice Test

Section I: Multiple Choice *Select the best answer for each question.*

T4.1 When we take a census, we attempt to collect data from

(a) a stratified random sample.

(b) every individual chosen in a simple random sample.

(c) every individual in the population.

(d) a voluntary response sample.

(e) a convenience sample.

T4.2 You want to take a simple random sample (SRS) of 50 of the 816 students who live in a dormitory on

campus. You label the students 001 to 816 in alphabetical order. In the table of random digits, you read the entries

95592 94007 69769 33547 72450 16632 81194 14873

The first three students in your sample have labels

(a) 955, 929, 400.
(b) 400, 769, 769.
(c) 559, 294, 007.
(d) 929, 400, 769.
(e) 400, 769, 335.

T4.3 A study of treatments for angina (pain due to low blood supply to the heart) compared bypass surgery, angioplasty, and use of drugs. The study looked at the medical records of thousands of angina patients whose doctors had chosen one of these treatments. It found that the average survival time of patients given drugs was the highest. What do you conclude?

(a) This study proves that drugs prolong life and should be the treatment of choice.
(b) We can conclude that drugs prolong life because the study was a comparative experiment.
(c) We can't conclude that drugs prolong life because the patients were volunteers.
(d) We can't conclude that drugs prolong life because this was an observational study.
(e) We can't conclude that drugs prolong life because no placebo was used.

T4.4 Tonya wanted to estimate the average amount of time that students at her school spend on Facebook each day. She gets an alphabetical roster of students in the school from the registrar's office and numbers the students from 1 to 1137. Then Tonya uses a random number generator to pick 30 distinct labels from 1 to 1137. She surveys those 30 students about their Facebook use. Tonya's sample is a simple random sample because

(a) it was selected using a chance process.
(b) it gave every individual the same chance to be selected.
(c) it gave every possible sample of the same size an equal chance to be selected.
(d) it doesn't involve strata or clusters.
(e) it is guaranteed to be representative of the population.

T4.5 Consider an experiment to investigate the effectiveness of different insecticides in controlling pests and their impact on the productivity of tomato plants. What is the best reason for randomly assigning treatment levels (spraying or not spraying) to the experimental units (farms)?

(a) Random assignment allows researchers to generalize conclusions about the effectiveness of the insecticides to all farms.
(b) Random assignment will tend to average out all other uncontrolled factors such as soil fertility so that they are not confounded with the treatment effects.
(c) Random assignment eliminates the effects of other variables, like soil fertility.
(d) Random assignment eliminates chance variation in the responses.
(e) Random assignment helps avoid bias due to the placebo effect.

T4.6 The most important advantage of experiments over observational studies is that

(a) experiments are usually easier to carry out.
(b) experiments can give better evidence of causation.
(c) confounding cannot happen in experiments.
(d) an observational study cannot have a response variable.
(e) observational studies cannot use random samples.

T4.7 A TV station wishes to obtain information on the TV viewing habits in its market area. The market area contains one city of population 170,000, another city of 70,000, and four towns of about 5000 inhabitants each. The station suspects that the viewing habits may be different in larger and smaller cities and in the rural areas. Which of the following sampling designs would give the type of information that the station requires?

(a) A cluster sample using the cities and towns as clusters
(b) A convenience sample from the market area
(c) A simple random sample from the market area
(d) A stratified sample from the cities and towns in the market area
(e) An online poll that invites all people from the cities and towns in the market area to participate

T4.8 *Bias* in a sampling method is

(a) any difference between the sample result and the truth about the population.
(b) the difference between the sample result and the truth about the population due to using chance to select a sample.
(c) any difference between the sample result and the truth about the population due to practical difficulties such as contacting the subjects selected.
(d) any difference between the sample result and the truth about the population that tends to occur in the same direction whenever you use this sampling method.
(e) racism or sexism on the part of those who take the sample.

T4.9 You wonder if TV ads are more effective when they are longer or repeated more often or both. So you design an experiment. You prepare 30-second and 60-second ads for a camera. Your subjects all watch the same TV program, but you assign them at random to four groups. One group sees the 30-second ad once during the program; another sees it three times; the third group sees the 60-second ad once; and the last group sees the 60-second ad three times. You ask all subjects how likely they are to buy the camera.

(a) This is a randomized block design, but not a matched pairs design.

(b) This is a matched pairs design.

(c) This is a completely randomized design with one explanatory variable (factor).

(d) This is a completely randomized design with two explanatory variables (factors).

(e) This is a completely randomized design with four explanatory variables (factors).

T4.10 A researcher wishes to compare the effects of two fertilizers on the yield of soybeans. She has 20 plots of land available for the experiment, and she decides to use a matched pairs design with 10 pairs of plots. To carry out the random assignment for this design, the researcher should

(a) use a table of random numbers to divide the 20 plots into 10 pairs and then, for each pair, flip a coin to assign the fertilizers to the 2 plots.

(b) subjectively divide the 20 plots into 10 pairs (making the plots within a pair as similar as possible) and then, for each pair, flip a coin to assign the fertilizers to the 2 plots.

(c) use a table of random numbers to divide the 20 plots into 10 pairs and then use the table of random numbers a second time to decide on the fertilizer to be applied to each member of the pair.

(d) flip a coin to divide the 20 plots into 10 pairs and then, for each pair, use a table of random numbers to assign the fertilizers to the 2 plots.

(e) use a table of random numbers to assign the two fertilizers to the 20 plots and then use the table of random numbers a second time to place the plots into 10 pairs.

T4.11 You want to know the opinions of American high school teachers on the issue of establishing a national proficiency test as a prerequisite for graduation from high school. You obtain a list of all high school teachers belonging to the National Education Association (the country's largest teachers' union) and mail a survey to a random sample of 2500 teachers. In all, 1347 of the teachers return the survey. Of those who responded, 32% say that they favor some kind of national proficiency test. Which of the following statements about this situation is true?

(a) Because random sampling was used, we can feel confident that the percent of all American high school teachers who would say they favor a national proficiency test is close to 32%.

(b) We cannot trust these results, because the survey was mailed. Only survey results from face-to-face interviews are considered valid.

(c) Because over half of those who were mailed the survey actually responded, we can feel fairly confident that the actual percent of all American high school teachers who would say they favor a national proficiency test is close to 32%.

(d) The results of this survey may be affected by nonresponse bias.

(e) The results of this survey cannot be trusted due to voluntary response bias.

Section II: Free Response *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.*

T4.12 Elephants sometimes damage trees in Africa. It turns out that elephants dislike bees. They recognize beehives in areas where they are common and avoid them. Can this be used to keep elephants away from trees? Will elephant damage be less in trees with hives? Will even empty hives keep elephants away? Researchers want to design an experiment to answer these questions using 72 acacia trees.[64]

(a) Identify the experimental units, treatments, and the response variable.

(b) Describe how the researchers could carry out a completely randomized design for this experiment. Include a description of how the treatments should be assigned.

T4.13 A *New York Times* article on public opinion about steroid use in baseball discussed the results of a sample survey. The survey found that 34% of adults think that at least half of Major League Baseball (MLB) players "use steroids to enhance their athletic performance." Another 36% thought that about a quarter of MLB players use steroids; 8% had no opinion. Here is part of the *Times*'s statement on "How the Poll Was Conducted":

> The latest New York Times/CBS News Poll is based on telephone interviews conducted March 15 through March 18 with 1,067 adults throughout the United States.... The sample of telephone numbers called was randomly selected by a computer from a list of more than 42,000 active residential exchanges across the country. The exchanges were chosen to ensure that each region of the country was represented in proportion to its population. In each exchange, random digits were added to form a complete telephone number, thus permitting access to listed and unlisted numbers. In each household, one adult was designated by a random procedure to be the respondent for the survey.[65]

(a) Explain why the sampling method used in this survey was *not* a simple random sample.

(b) Why was one adult chosen at random in each household to respond to the survey?

(c) Explain how undercoverage could lead to bias in this sample survey.

T4.14 Many people start their day with a jolt of caffeine from coffee or a soft drink. Most experts agree that people who take in large amounts of caffeine each day may suffer from physical withdrawal symptoms if they stop ingesting their usual amounts of caffeine. Researchers recruited 11 volunteers who were caffeine dependent and who were willing to take part in a caffeine withdrawal experiment. The experiment was conducted on two 2-day periods that occurred one week apart. During one of the 2-day periods, each subject was given a capsule containing the amount of caffeine normally ingested by that subject in one day. During the other study period, the subjects were given placebos. The order in which each subject received the two types of capsules was randomized. The subjects' diets were restricted during each of the study periods. At the end of each 2-day study period, subjects were evaluated using a tapping task in which they were instructed to press a button 200 times as fast as they could.[66]

(a) How and why was blocking used in the design of this experiment?

(b) Why did researchers randomize the order in which subjects received the two treatments?

(c) Could this experiment have been carried out in a double-blind manner? Explain.

Cumulative AP® Practice Test 1

Section I: Multiple Choice *Choose the best answer for Questions AP1.1 to AP1.14.*

AP1.1 You look at real estate ads for houses in Sarasota, Florida. Many houses range from $200,000 to $400,000 in price. The few houses on the water, however, have prices up to $15 million. Which of the following statements best describes the distribution of home prices in Sarasota?

(a) The distribution is most likely skewed to the left, and the mean is greater than the median.

(b) The distribution is most likely skewed to the left, and the mean is less than the median.

(c) The distribution is roughly symmetric with a few high outliers, and the mean is approximately equal to the median.

(d) The distribution is most likely skewed to the right, and the mean is greater than the median.

(e) The distribution is most likely skewed to the right, and the mean is less than the median.

AP1.2 A child is 40 inches tall, which places her at the 90th percentile of all children of similar age. The heights for children of this age form an approximately Normal distribution with a mean of 38 inches. Based on this information, what is the standard deviation of the heights of all children of this age?

(a) 0.20 inches (c) 0.65 inches (e) 1.56 inches

(b) 0.31 inches (d) 1.21 inches

AP1.3 A large set of test scores has mean 60 and standard deviation 18. If each score is doubled, and then 5 is subtracted from the result, the mean and standard deviation of the new scores are

(a) mean 115; std. dev. 31. (d) mean 120; std. dev. 31.

(b) mean 115; std. dev. 36. (e) mean 120; std. dev. 36.

(c) mean 120; std. dev. 6.

AP1.4 For a certain experiment, the available experimental units are eight rats, of which four are female (F1, F2, F3, F4) and four are male (M1, M2, M3, M4). There are to be four treatment groups, A, B, C, and D. If a randomized block design is used, with the experimental units blocked by gender, which of the following assignments of treatments is impossible?

(a) A → (F1, M1), B → (F2, M2), C → (F3, M3), D → (F4, M4)

(b) A → (F1, M2), B → (F2, M3), C → (F3, M4), D → (F4, M1)

(c) A → (F1, M2), B → (F3, F2), C → (F4, M1), D → (M3, M4)

(d) A → (F4, M1), B → (F2, M3), C → (F3, M2), D → (F1, M4)

(e) A → (F4, M1), B → (F1, M4), C → (F3, M2), D → (F2, M3)

AP1.5 For a biology project, you measure the weight in grams (g) and the tail length in millimeters (mm) of a group of mice. The equation of the least-squares line for predicting tail length from weight is

$$\text{predicted tail length} = 20 + 3 \times \text{weight}$$

Which of the following is *not* correct?

(a) The slope is 3, which indicates that a mouse's weight should increase by about 3 grams for each additional millimeter of tail length.

(b) The predicted tail length of a mouse that weighs 38 grams is 134 millimeters.

(c) By looking at the equation of the least-squares line, you can see that the correlation between weight and tail length is positive.