

Now we consider option (2), which we will see is more economical. Suppose you were to first use a simple random sample to choose 100 counties and that next you choose a simple random sample of 8 people in each county. The cost of hiring the interviewers would be $(100)(\$50) = \5000 for the 100 different counties. Again, you will need to pay \$10 for each interview conducted, that is, $(800)(\$10) = \8000 . Thus, the total cost under this plan would be $\$5000 + \$8000 = \$13,000$, which is \$2000 under your budgeted amount.

Option (2) is an example of **multistage sampling**, which is a sampling method that uses successive applications of the sampling methods we have discussed.

PROBLEM SET 9.2

1. For each of the following samples, indicate which sampling technique was used.
 - a. A newspaper randomly selected 80 urban and 80 rural residents and interviewed them about the governor's new tax proposal.
 - b. A scientist surveyed every seventh person entering a fast-food restaurant about his or her sleeping habits.
 - c. A farmer divided a map of field corn into nonoverlapping regions. He randomly selected six of the regions and examined all the corn plants in each region for pest infestation.
 - d. Forty percent of women who gave birth in a certain hospital had cesarean sections. An independent analyst surveyed 300 women who recently gave birth to assess their level of satisfaction with the care they received. Of the 300 women in the sample, the analyst randomly selected 120 women from the group who had cesarean sections, and 180 women from the group who did not.
2. For each of the following samples, indicate which sampling technique was used.
 - a. A quality-control inspector selected every 20th DVD player as it came off an assembly line.
 - b. A consulting firm randomly selected 90 patients of all patients who were treated at a certain hospital in the past year and interviewed them about their satisfaction with patient care.
 - c. A city planner divided a city into parcels measuring 1 city block by 1 city block. Fifty parcels were randomly selected and everyone in each parcel was interviewed about a recent flood.
 - d. An airport security guard rolled a die for every person who passed through a security check point. If the die landed with a 1 showing, the guard selected that person for a more detailed security screening.
3. An opinion pollster will take a sample of people entering a shopping mall. For each person passing through the door, the pollster will flip a coin. If the coin shows heads, then the person will be selected for the sample. Suppose the coin is flipped 200 times and shows heads 75 times.
 - a. What percent of the first 200 people entering the mall are included in the sample?
 - b. Is this a 50% independent sample? Explain.
4. A border guard at a certain checkpoint will take a sample of cars passing from the United States into Canada. For each car that stops at the checkpoint, the guard will flip a coin. If the coin shows tails, then the car will be selected for the sample. Suppose the coin is flipped 65 times and shows tails 48 times.
 - a. What percent of the first 65 cars stopping at the checkpoint are included in the sample?
 - b. Is this a 50% independent sample? Explain.
5. A jury-duty coordinator will send notices to a sample of the 2345 registered voters of a small town. In order to have a sufficiently large pool of potential jurors, the coordinator has to send notices to 20% of the registered voters. Explain why a 20% independent sample might not be a good choice of method for this jury-duty selection process.
6. A pollster will conduct an opinion poll to assess the approval rating for the governor of Utah. The pollster will select at least 1000 of the 1 million registered voters in Utah to participate in the poll. Explain why a 0.1% independent sample might not be a good choice of method for this opinion poll selection process.

Problems 9 through 14

Governors for each of the 50 United States in 2004 are given in the following table. Label the governors alphabetically by state, as listed in the table, so that the Alabama governor Robert Riley is 1 and continue until the Wyoming governor is 50.

9. Find a 20% independent sample from the governors of the United States in 2004. Use the digits 0 and 1 to mean "select this governor," and proceed down the second column of the table in Figure 9.4, beginning in row 101 and going from left to right.
10. Find a 20% independent sample from the governors of the United States in 2004. Use the digits 8 and 9 to mean "select this governor," and proceed down the sixth column of the table in Figure 9.4, beginning in row 101 and going from left to right.

7. In Example 9.9, we used the first column of digits to find a 10% independent sample from a set of 100 automobiles. Repeat the process illustrated in the example using 0 to mean "select this car," but this time find a 10% independent sample using the third column of digits from the table in Figure 9.4, beginning at the top of the column.
 - a. Find a 10% independent sample using the third column of digits from the table in Figure 9.4, beginning at the top of the column.
 - b. Find a 20% independent sample of the letters of the alphabet ($A = 1, B = 2, \dots, Z = 26$) using the third column of digits from the table in Figure 9.4, beginning at the top of the column. Use the digits 1 and 2 to mean "select this letter."
8. Find a 20% independent sample of the letters of the alphabet ($A = 1, B = 2, \dots, Z = 26$) using the third column of digits from the table in Figure 9.4, beginning at the top of the column and reading row by row down the column. Use the digits 1 and 2 to mean "select this letter."

U.S. GOVERNORS, 2004	
Alabama: Robert Riley	Montana: Judy Martz
Alaska: Frank Murkowski	Nebraska: Mike Johanns
Arizona: Janet Napolitano	Nevada: Kenny Guinn
Arkansas: Mike Huckabee	New Hampshire: Craig Benson
California: Arnold Schwarzenegger	New Jersey: James McGreevey
Colorado: Bill Owens	New Mexico: Bill Richardson
Connecticut: John Rowland	New York: George Pataki
Delaware: Ruth Ann Minner	North Carolina: Michael Easley
Florida: Jeb Bush	North Dakota: John Hoeven
Georgia: Sonny Perdue	Ohio: Bob Taft
Hawaii: Linda Lingle	Oklahoma: Brad Henry
Idaho: Dirk Kempthorne	Oregon: Ted Kulongoski
Illinois: Rod Blagojevich	Pennsylvania: Edward Rendell
Indiana: Joseph Kernan	Rhode Island: Don Carcieri
Iowa: Thomas Vilsack	South Carolina: Mark Sanford
Kansas: Kathleen Sebelius	South Dakota: Mike Rounds
Kentucky: Ernie Fletcher	Tennessee: Phil Bredesen
Louisiana: Kathleen Blanco	Texas: Rick Perry
Maine: John Baldacci	Utah: Olene Walker
Maryland: Robert Ehrlich	Vermont: James H. Douglas
Massachusetts: Mitt Romney	Virginia: Mark Warner
Michigan: Jennifer Granholm	Washington: Gary Locke
Minnesota: Tim Pawlenty	West Virginia: Bob Wise
Mississippi: Haley Barbour	Wisconsin: Jim Doyle
Missouri: Bob Holden	Wyoming: Dave Freudenthal

Source: National Governors Association.

11. a. Find a 30% independent sample from the governors of the United States in 2004. Use the digits 1, 2, and 3 to mean "select this governor." Use the second column of the table in Figure 9.4. Read down the column beginning in row 130, and go from left to right, row by row.
 b. What percentage of governors was actually included in your sample from part (a)?
12. a. Find a 50% independent sample from the governors of the United States in 2004. Use the digits 0, 1, 2, 3, and 4 to mean "select this governor." Use the third column of the table in Figure 9.4. Read down the column beginning in row 130, and go from left to right, row by row.
 b. What percentage of governors was actually included in your sample from part (a)?
13. Suppose you took an independent sample with the resulting sample yielding only the governors from Illinois and Missouri. To generate the independent sample, you used the following entries from a random-number table.
- | | | | | |
|-------|-------|-------|-------|-------|
| 04212 | 40076 | 30584 | 93939 | 39665 |
| 74781 | 88341 | 03617 | 10099 | 88296 |
- Describe this independent sample in terms of percentages by filling in the blank below.
- This sample was a ____% independent sample.
14. Suppose you took an independent sample and the result was that the sample consisted of the governors from Arizona, Connecticut, New Jersey, New Mexico, and Virginia. To generate the independent sample, you used the following entries from a random-number table.
- | | | | | |
|-------|-------|-------|-------|-------|
| 77175 | 80925 | 23629 | 77764 | 75867 |
| 32931 | 07544 | 95693 | 34646 | 13994 |
- Describe this independent sample in terms of percentages by filling in the blank below.
- This sample was a ____% independent sample.
15. Suppose you use a 1-in-15 systematic sampling to pick a sample from 180 printers coming off an assembly line and that you pick the number 9 at random to start the systematic sample.
- What is the value of k in this sampling process and what is its significance?
 - What is the value of r in this sampling process and what is its significance?
 - If the printers are numbered 1 to 180, which printers are included in the sample?
16. Suppose you use a 1-in-20 systematic sampling to pick a sample from 250 blocks of cheese on a conveyor belt and that you pick the number 11 at random to start the systematic sample.
- What is the value of k in this sampling process and what is its significance?
 - What is the value of r in this sampling process and what is its significance?
 - If the blocks of cheese are numbered 1 to 250, which ones are included in the sample?
17. Use 1-in-10 systematic sampling to pick a sample from the 50 governors shown in the table after problem 10. Use the fourth digit from the first column in row 128 of the table in Figure 9.4 to start the systematic sample.
18. Use 1-in-10 systematic sampling to pick a sample from the 50 governors shown in the table after problem 10. Use the fifth digit from the sixth column in row 136 of the table in Figure 9.4 to start the systematic sample.
19. Pick a sample of letters of the alphabet using 1-in-5 systematic sampling. Use the table in Figure 9.4, beginning in column 3 and row 102. Select the first digit from 1 through 5 in the table to start the systematic sampling. Label the letters of the alphabet, using the natural order of the alphabet, with $A = 1$, and list the letters that are included in the sample.
20. Pick a sample of letters of the alphabet using 1-in-3 systematic sampling. Use the table in Figure 9.4 and begin in column 6 and row 115. Select the first digit from 1 through 3 in the table to start the systematic sampling. Label the letters of the alphabet in alphabetical order with $A = 1$, and list the letters that are included in the sample.
21. Suppose a theater owner hands a questionnaire to the 9th, 19th, 29th, 39th, 49th, and 59th adults who leave the theater.
- What kind of survey did the theater owner conduct? Be specific.
 - Can you determine how many adults were in the theater? Explain.
22. Suppose a catalog company records the 8th, 23rd, 38th, . . . , and 208th calls to its customer service department in 1 day.
- What kind of survey did the company conduct? Be specific.
 - Can you determine how many calls the company made on that day? Explain.

27. Suppose that a class consists of 80 women and 80 men. You wish to survey the class to determine which movies to show in a foreign film series. Since men and women may have different tastes, you decide to take a stratified sample of 10 men and 10 women from the class.

a. Identify the strata in this sample.

b. Number the men from 01 to 80 and the women from 01 to 80. Use the table in Figure 9.4 to choose the sample. Use the second and third digits of column 2 for men and the second and third digits of column 3 for the women. Begin in row 13 in each case, and read down the column.

28. Suppose there are 240 freshmen, 220 sophomores, 232 juniors, and 184 seniors in a small college. You plan to take a stratified random sample of 4 focus groups of size 6 students from each class.

a. Identify the strata in this sample.

b. Number the students in each class with three digits, beginning with 001. Use the table in Figure 9.4 to select the samples. Begin using the first three digits of column 2 in row 107 and read down the column to select the sample of freshmen. After you've selected the last freshman, begin on the next row to pick the sample of sophomores, and continue in this manner.

29. A small college has an enrollment of 2000. Of these, 950 are freshmen and sophomores, 800 are juniors and seniors, and 250 are graduate students. The administration takes a stratified random sample of size 40 to ask their opinion about a proposed "technology fee" for upgrading computer facilities.

a. Identify the strata in this sample and comment on the likelihood that members of each stratum will have opinions that are more homogeneous than the general population.

b. The administration wants the proportion of each stratum in the sample to be the same as in the population. How many students should be selected from each stratum? Explain your reasoning.

c. Number the freshmen and sophomores from 001 to 950, and the other groups similarly. Use your answer in (b) and the table in Figure 9.4 to select the samples. Use column 1 for the freshmen and sophomores, column 3 for the juniors and seniors, and column 5 for the graduate students. Begin with the first three digits in row 105 in each case and read down the column.

23. In 2002, approximately 141,661,000 males and 146,708,000 females were living in the United States, according to the U.S. Census Bureau. If you plan to conduct a quota sample of size 800 such that the percentage of males and females in the sample is the same as the percentage in the general population, how many males and how many females should you include in the sample?

24. In 2002, approximately 288,369,000 people were living in the United States. The following table contains population information listed by race. If you plan to conduct a quota sample of size 5000 such that the percentages of each race in the sample is the same as the percentages in the general population, then how many people of each race should you include in the sample?

Race	Population
African American	36,746,000
American Indian and Alaska Native	2,752,000
Asian	11,559,000
Caucasian	232,647,000
Native Hawaiian and Pacific Islander	484,000
Two or more races	4,181,000

Source: U.S. Census Bureau

25. In 2002, according to the U.S. Census Bureau, approximately 18.8% of the population lived in the Northeast, 22.6% lived in the Midwest, 35.8% lived in the South, and 22.8% lived in the West. Suppose an opinion poll uses a quota sample in which the percentages of people in the sample living in each region of the country are the same as the percentages in the general population. How might the results of the survey be affected if all the people surveyed from the South lived in Florida?

26. Suppose an opinion poll uses a quota sample in which the percentages of males and females in the sample are the same as the percentages in the general population. How might the results of the survey be affected if all the males included in the survey are interviewed by phone between the hours of 8 A.M. and 3 P.M.?

30. An obstetrician has 156 expectant patients. Of the obstetrician's patients, 75 are expecting their first child, 54 their second, and 27 their third. The doctor would like to take a stratified random sample of 25 of her patients to ask their opinion about a new type of pain relief drug available to women in labor.
- Identify the strata in this sample and comment on the likelihood that members of each stratum will have opinions that are more homogeneous than the general population.
 - The doctor wants the proportion of each stratum in the sample to be the same as in the population. How many patients should be selected from each stratum? Explain your reasoning.
 - Number the patients who are expecting their first child from 01 to 75, and the other patients similarly. Use your answer in (b) and the table in Figure 9.4 to select the samples. Use column 2 for the patients expecting their first child, column 3 for the patients expecting their second child, and column 4 for the patients expecting their third child. Begin with the last two digits in row 117 in each case and read down the column.

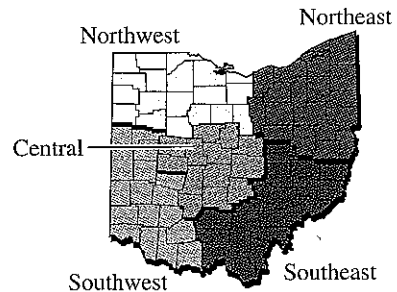
31. The Albany College of Pharmacy has a student body of approximately 700. Suppose the campus dormitory houses three students in each of the 80 rooms. A student will conduct a survey to determine dormitory residents' opinions about a campus issue. The student will interview a total of 60 residents from the dormitory. Use cluster sampling to select the sample.

- Identify the sampling units and determine how many sampling units will be selected.
- Number the rooms 01 to 80. Use the second and third digits of column 2 in the table in Figure 9.4, beginning in row 115 going down the column. Which rooms are selected in the sample?

32. As part of a research project, you will investigate how many chocolate chips are in Moonbeam Chocolate Chip Cookies. The nearby convenience store has 30 packages of these cookies, and each package contains 12 cookies. You will examine a total of 72 cookies. Use cluster sampling to select the sample.

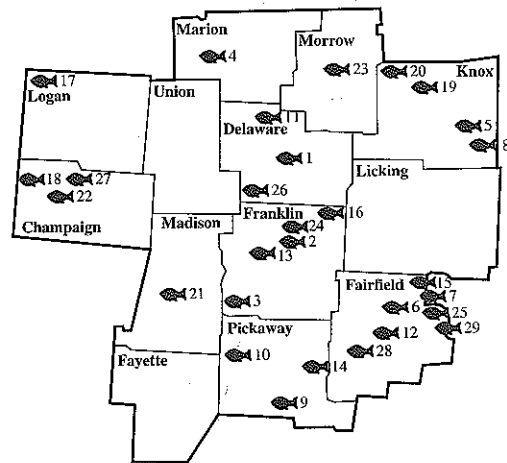
- Identify the sampling units and determine how many sampling units will be selected.
- Number the packages 01 to 30. Use the fourth and fifth digits of column 4 in the table in Figure 9.4, beginning in row 128 going down the column. Which packages are selected in the sample?

33. In the state of Ohio, people aged 16 to 66 must have a fishing license in order to fish in any public water. Suppose the Ohio Division of Wildlife wants to investigate the use of fishing licenses. The following map shows how Ohio is broken into five regions: Northwest, Northeast, Southwest, Southeast, and Central. Each Ohio region is broken up into counties.



Source: www.dnr.state.oh.us/wildlife/fishing/lakemaps/lmaps.htm.

- Describe how to use cluster sampling to study the use of public water fishing licenses if regions are used as clusters.
- The following map shows all 13 counties and 29 public waters in the central region of Ohio. The numbered fish in the map indicate the locations of public waters in each county. Give at least two reasons why cluster sampling, with counties as clusters, might be a poor sampling choice for this study.



- Select a simple random sample of 10 public waters in central Ohio. Use the second and third digits of the second column beginning in row 125 of the table in Figure 9.4 and go down the column.

- 01 02 03 04 05 06 07 08 09 10 11 12
 13 14 15 16 17 18 19 20 21 22 23 24
 25 26 27 28 29 30 31 32 33 34 35 36
 37 38 39 40 41 42 43 44 45 46 47 48

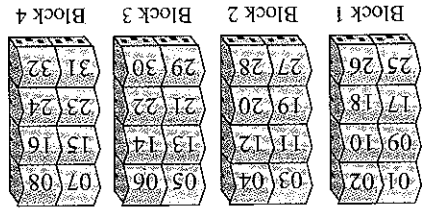
a. Select a 40% independent sample. Use the table in Figure 9.4. Begin in column 1 of row 109 and read across the row. Let the digits 1, 2, 3, and 4 indicate that the tree will be selected for the sample. List the trees that you selected and shade the selected trees in the diagram. What percentage of trees did you select? How much will it cost to inspect the trees in the sample?

b. Select a simple random sample of 16 trees. Use the table in Figure 9.4. Beginning in column 4 of row 135, use the first two digits in the row and read down the column. List the trees that you selected and shade the selected trees in the diagram. What percentage of trees did you select? How much will it cost to inspect the trees in the sample?

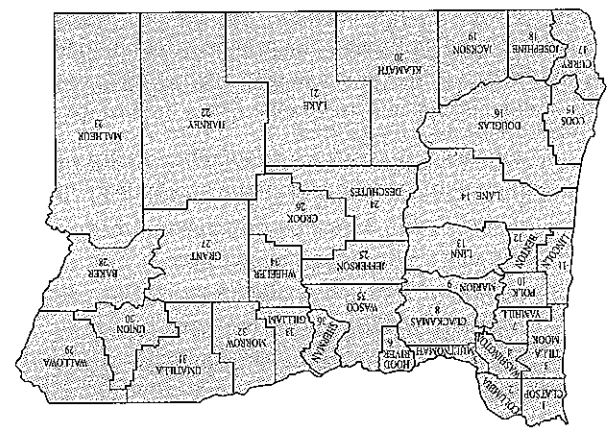
c. Select a 1-in-3 systematic sample. Use the fourth digit in column 3 of row 142 of the table in Figure 9.4 to begin in the sample. List the trees that you selected and shade the selected trees in the diagram. What percentage of trees did you select? How much will it cost to inspect the trees in the sample?

d. Compare the selected trees in parts (a), (b), and (c). Which sampling method do you think is the most appropriate to use in this case? Explain.

36. The owner of a complex of 32 townhouses, which are numbered from 01 through 32 as shown in the following diagram, is willing to pay for 16 termite inspections. The eight townhouses in each block are connected.

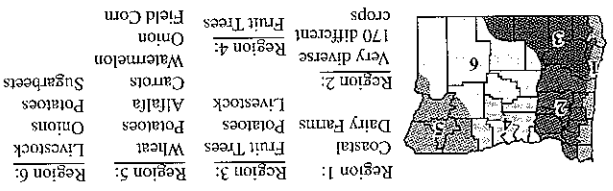


34. Suppose the Department of Agriculture in the state of Oregon wants to monitor pesticide use for field crops by farms in the state. The following map numbers the 36 counties of Oregon. Over 40,000 farms are in Oregon, with some farms in each of the 36 counties.



Source: U.S. Census Bureau, County Maps

- Explain why the Department of Agriculture might want to use cluster sampling rather than taking a simple random sample of farms.
- Use the first and second digits of column 4 in the table in Figure 9.4, beginning in row 122, going down the column to select a cluster sample of 10 counties.
- The following map shows Oregon's growing regions; the list describes the main farming industries for each region. Explain how stratified random sampling could be used to investigate pesticide use.



Source: Oregon Department of Agriculture

35. A farmer maps her fruit tree orchard and numbers the trees as shown in the following diagram. To monitor for disease, she will take a sample of trees and visually inspect each tree in the sample. It will take 30 minutes per tree to examine for disease, at a cost of \$35 per hour.

- a. Select a simple random sample of 16 of the townhouses. Use the second and third digits in column 5 of row 116 in the table in Figure 9.4, and read down the column. List the townhouses that you selected and shade the selected townhouses in the diagram.
 - b. If you assume that each block of eight townhouses is homogeneous, then the townhouses form four strata. Select a stratified random sample by randomly sampling 4 townhouses in each stratum. Use the table in Figure 9.4. For block 1, use the last two digits of column 1 in row 104 and read down the column. For block 2, use the last two digits of column 3 in row 101. For block 3, use the first two digits of column 2 in row 103. For block 4, use the first two digits of column 3 in row 102. List the townhouses that you selected and shade the selected townhouses in the diagram.
 - c. Select a cluster sample using blocks as clusters. Use the table in Figure 9.4 to select the sample. Begin in column 2 of row 110 and read across the row. List the townhouses that you selected and shade the selected townhouses in the diagram.
 - d. Compare the selected townhouses in parts (a), (b), and (c). Which sampling method do you think is the most appropriate to use in this case? Explain.
37. Suppose the Centers for Disease Control and Prevention (CDC) want to conduct a survey to determine health habits of children in a certain state. For each scenario below, identify the sampling technique described and discuss the pros and cons of using that sampling technique for the survey.
- a. The CDC randomly selects several cities in the state and interviews all children in every school of each selected city.
 - b. The CDC lists all the schools in the state, randomly selects a certain number of schools from the list, and interviews every child in each of the selected schools.
 - c. The CDC lists every school-age child in the state, randomly selects a certain number of children from the list, and interviews each child selected.
 - d. The CDC divides the state into urban and rural areas, randomly selects a fixed number of schools from both areas, and interviews all the children in each selected school.
38. Suppose a fruit tree grower would like to assess the level of pest infestation in his crop of fruit trees. For each part below, identify the sampling technique described and discuss the pros and cons of using that sampling technique for the study.
- a. The grower randomly selects a tree to examine and then moves row by row through the orchard, selecting every 15th tree for inspection.
 - b. For each tree, the grower flips a coin. If the coin lands heads, the grower inspects the tree.
 - c. The grower numbers each row of trees, randomly selects a certain number of rows, and inspects every tree in those rows.
 - d. Each tree is numbered, and a certain number of trees are randomly selected for inspection.
39. Advisors to the President are considering a new tax break for adults who have children. Before taking action, they would like to determine public opinion about the tax break, so they will take a sample of 350 adults. Describe a sampling technique that would be appropriate to use in this situation, and give reasons for your selection.
40. A snack factory makes potato chips, tortilla chips, and pretzels and packages them in lunch-size bags. Daily factory production is 35% potato chips, 40% tortilla chips, and 25% pretzels. A sample of size 100 will be selected to estimate how many bags are underweight. Describe a sampling technique that would be appropriate to use in this situation, and give reasons for your selection.
41. Suppose a new warning label is being considered for placement on packages of cigarettes. The Surgeon General calls for a survey to be conducted to determine the effectiveness of the warning label. A sample of size 500 will be taken. Describe a sampling technique that would be appropriate to use in this situation, and give reasons for your selection.
42. A university would like to survey recent graduates to determine average salaries. In the past year, 1700 students graduated with bachelor's degrees, 650 with master's degrees, and 45 with doctor's degrees. The university wants to sample 200 graduates. Describe a sampling technique that would be appropriate to use in this situation, and give reasons for your selection.