### Data Set to be Used for Many Examples

The 2015 Atlantic hurricane season was notable for many reasons, among them the most named storms and the most hurricanes.

| **Number** | **Name** | **Max wind speed** | **Classification** | **Atlantic or**  **Pacific** |
| --- | --- | --- | --- | --- |
| 1 | Ana | 60 | S | A |
| 2 | Bill | 60 | S | A |
| 3 | Claudette | 50 | S | A |
| 4 | Danny | 115 | H | A |
| 5 | Ela | 45 | S | P |
| 6 | Erika | 50 | S | A |
| 7 | Fred | 85 | H | A |
| 8 | Grace | 50 | S | A |
| 9 | Guillerma | 105 | H | P |
| 10 | Halola | 65 | S | P |
| 11 | Henri | 50 | S | A |
| 12 | Hilda | 140 | H | P |
| 13 | Ida | 50 | S | A |
| 14 | Ignacio | 145 | H | P |
| 15 | Iune | 40 | S | P |
| 16 | Jimena | 120 | H | P |
| 17 | Joaquin | 155 | H | A |
| 18 | Kate | 75 | H | A |
| 19 | Kilo | 140 | H | P |
| 20 | Loke | 75 | H | P |
| 21 | Malia | 40 | S | P |
| 22 | Niala | 65 | S | P |
| 23 | Oho | 95 | H | P |
|  | S = Storm H = Hurricane A = Atlantic and P = Pacific | | | |
|  |  |  |  |  |

# 14 - 1. Common Sampling Techniques

## Objective 1. Demonstrate a Knowledge of the Four Basic Sampling Methods.

Recall that a population is defined as all individuals, human or otherwise, under \_\_\_\_\_\_\_\_\_\_\_\_. Populations are generally very \_\_\_\_\_\_\_\_\_\_, making it impossible to use every individual, so a sample must be selected. A sample is a \_\_\_\_\_\_\_\_\_\_\_\_\_ of the population. Any subgroup can be a sample, but for researchers to make valid inferences about population characteristics, the sample must be \_\_\_\_\_\_\_\_\_\_\_.

### Definition: Random Sample

A sample is a random sample when every member of the population must have an \_\_\_\_\_\_\_\_\_\_\_\_\_ chance of being selected.

When a sample is at random from a population, it is considered \_\_\_\_\_\_\_\_\_\_\_\_\_ and is, most likely, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the population.

### Biased Samples

A biased sample is a sample that is chosen in a way that a systematic \_\_\_\_\_\_\_\_ is made in the selection of the individuals.

Sampling or selection bias occurs when some subjects are \_\_\_\_\_\_\_\_\_\_ likely to be included than others.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ bias occurs when subjects who do not respond to a survey question would answer it differently than those who do respond to it.

Response or interviewer bias occurs when the subject gives a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ response than he or she really believes.

Volunteer bias occurs when volunteers are used since they might be more \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in the survey or study and answer questions or participate differently than randomly selected subjects.

### Reasons for Using Samples

1. It saves the researcher \_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_.
2. It enables the researcher to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ that might otherwise not be available.
3. It enables the researcher to get more \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ information about a particular subject.

The best sample would reflect population characteristics perfectly. However, this is impossible to achieve. The best alternative is to select a sample that is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ with respect to some of the characteristics of interest.

To obtain the best unbiased samples, several basic sampling methods have been developed. The most common sampling methods are random, systematic, stratified, and cluster sampling.

### Random Sampling

A random sample is obtained by using methods such as \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ numbers, which can be found using tables, computers, or calculators.

The basic requirement of random sampling is that, for a sample of size *n*, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ samples of this size have the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of being selected from the population.

There are several incorrect techniques that are commonly mistaken for random sampling. These include asking people who are available at the time of the interview, ask a question by radio or television and ask viewers to call in to express their opinions, or including those who respond to a survey by mail or email. These methods do not obtain random sampling since all possible samples of a specific size do not have an \_\_\_\_\_\_\_\_\_\_ chance of being selected.

Random samples can be obtained one of two methods.

The first is to number each element of the population, place the numbers on cards that are placed in a hat or bowl, mixed well and then selected by drawing out as many cards as needed for the sample. The individuals associated with the drawn numbers are in the sample. It is important to ensure that the cards are \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_.

The second, preferred, method is to use random numbers. A sequence of random numbers is generated using technology or a table and including individuals associated with those numbers until a sample of the size required is selected.

### Table of Random Numbers.

The table is a two digit random number table that was generated by a computer.  A detailed random number table is in Table D of Appendix A of the textbook.  The theory behind random numbers is that each of the digits has the same chance of occurring, so 1/10 throughout the table, even if occurring more or less for a particular sequence.  To obtain a sample of random numbers, number hte elements of the population sequentially and select each person by  using random numbers.

Random samples can be selected with or without \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. If the same member of the population cannot be used more than once in the study, the sample is selected without replacement. Samples should be selected from \_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ populations. Small samples will be used in the examples for illustrative purposes only.

### Example 14-1. Select a Random Sample of Storms

Select a random sample of eight storms by using random numbers. Use the list of storms for 2015 as the population. Find he average maximum wind speed and compare the sample maximum wind speed with the population maximum wind speed.

*Solution*

The population mean maximum wind speed is \_\_\_\_\_\_\_\_\_\_\_\_.

**Step 1** Number the population.  
The population is numbered from 1 to 23 in the order the storms occurred.

**Step 2** Randomly select a starting point on the random number table.

Randomly selecting a starting point is generally done by closing one’s eyes and placing a finger anywhere on the table. That point is the starting point. Since our population is small, only two digit numbers are needed. The numbers in each column can represent the choice. Any value \_\_\_\_\_\_\_\_\_\_\_ than 23 will be ignored, so numbers must be selected until eight numbers between 1 and 23 are selected. For single digit values, the first number in the pair is zero. For example, 04 represents 4.

For this example, I have randomly selected the 69 that is the 12th value in the third column as the starting place. Following the rest of column 3 and continuing to column 4, list the numbers and select the values, \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, that correspond to 8 values between 1 and 23:

69 73 53 44 85 43 **15** 93 **13** 30 69

30 50 67 68 96 37 69 97 **19** 27 95

27 73 60 43 56 34 93 **06** 93 65 62

82 **~~13~~** 29 75 **01** 80 62 39 **23** 35 30

**20** 27 76 33 31 73 30 62 99 **~~01~~** 80

62 39 **~~23~~** 35 50 **~~20~~** 27 76 33 31 73

30 62 99 **~~01~~** 76 55 **~~15~~** 93 53 75 **04**

Eight values have been randomly selected: 15, 13, 19, 6, 1, 23, 20, 4.

Notice that values not between 1 and 23 are ignored and repeated values between 1 and 23 are included only once.

**Step 3** List the sample

**# Name Max Wind Speed**

1

4

6

13

15

19

20

23

**Step 4** Find the sample maximum wind speed

Recall that the population mean is \_\_\_\_\_\_\_\_\_\_\_\_\_.

The sample mean is slightly \_\_\_\_\_\_\_\_\_ than the population mean. Since the population standard deviation is \_\_\_\_\_\_\_\_\_\_\_, the sample mean is less than \_\_\_\_\_\_\_\_ standard deviation below the mean and less than \_\_\_\_\_\_\_ standard error(s) of the mean of \_\_\_\_\_\_\_\_\_\_\_ below the mean. Therefore, it (is / is not) a reasonable approximation of the mean.

(Answers with different starting points will vary.)

### Systematic Sampling

A systematic sample is a sample obtained by (1) numbering each element in the population (2) selecting some \_\_\_\_\_\_\_\_\_\_\_ starting point, and (3) then selecting every *\_\_\_\_\_\_* element (third, or fifth, or tenth, etc.) from the population to be included in the sample.

### Example 14-2. Select a Systematic Sample of Storms

Select a systematic sample of eight storms and calculate the average maximum wind speed. Compare with the population mean.

*Solution*

Twenty-three divided by 8 is 2.875 which is close to three. Randomly select a number between 1 and 3.

If 3 is chosen, there will only be \_\_\_\_\_ in the sample.

For this example, 2 was randomly selected.

Thus, we start with the second value.

Adding three to each succeeding value seven times yields \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The eight names associated with these are \_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_.

The maximum wind speed values associated with these storms are \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

The sample mean maximum wind speed is \_\_\_\_\_\_\_\_\_\_.

The population mean is 81.522.

The sample mean is slightly \_\_\_\_\_\_\_\_\_\_\_\_\_, but it is within \_\_\_\_\_\_\_\_\_ standard error of the mean, so it (is / is not) a reasonable approximation.

An advantage of systematic sampling is that it is \_\_\_\_\_\_\_\_ to select the sample elements. Also, the numbered list may already exist.

A disadvantage is that the list may be arranged in such a way that the sample may \_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_ individuals who have a certain characteristic, such as when a value is selected to start is even or odd and the number to add is even or odd could produce a sample that leaves a group out, such as a list arrange by Husband, Wife, Husband, Wife, …, starting on an odd and adding an even number would produce a sample with only husbands.

### Stratified Sampling

A stratified sample is a sample obtained by dividing the population into \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, called strata, according to various homogeneous (similar) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and then randomly selecting members from \_\_\_\_\_\_\_\_ stratum for the sample.

### Example 14-3. Select a Stratified Sample of Storms

Divide the 23 storms into 4 \_\_\_\_\_\_\_\_\_\_\_, by storm and ocean. Then select a sample of two storms from \_\_\_\_\_\_\_\_\_ group. Use the selected storms as the stratified sample. Compute the mean of the sample and compare it to the population mean.

*Solution*

**Step 1** Divide the population into the subgroups.

Keep the storms in the order in which they occurred.

| **Atlantic Storm** | **Atlantic Hurricane** | **Pacific Storm** | **Pacific Hurricane** |
| --- | --- | --- | --- |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

**Step 2** Select two students from each group by using random numbers.

The random numbers chosen for this example are:

Atlantic Storm: storms 1 & 3

Atlantic Hurricane: storms 4 & 1

Pacific Storm: storms 4 & 5

Pacific Hurricane: storms 2 & 3

The stratified sample of maximum wind speeds includes \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**Step 3** Find the mean of the sample and compare it to the population mean, 81.522.

The sample mean is \_\_\_\_\_\_\_\_ the population mean, but the difference is less than \_\_\_\_\_\_\_ standard error of the mean, so the sample mean (is / is not) a reasonable approximation of the mean.

The major advantage of stratified sampling is that it ensures representation of all population \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ that are important to the study.

One drawback is that if there are many variables of interest, dividing a large population into \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ subgroups takes a lot of effort. Another drawback is that if some variables are somewhat complex or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, such as beliefs, attitudes, or prejudices, it is difficult to separate individuals into the subgroups by those variables.

### Cluster Sampling

A cluster sample is a sample obtained by selecting a preexisting or natural \_\_\_\_\_\_\_\_\_\_\_\_\_\_, called a cluster, and using the members in the chosen clusters for the sample.

For example, studies in education often use existing classes, such as a selecting several of the classes from a population of all seventh grade classes in a certain county. All of the seventh graders in the selected classes are included in the sample.

The advantages of using a cluster sample include \_\_\_\_\_\_\_\_\_ reduction, simplification of the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and convenience. The major disadvantage is that the elements in a cluster may not have the same \_\_\_\_\_\_\_\_\_\_\_\_\_\_ in characteristics as elements selected individually from a population because groups of people may be more alike in specific clusters. For instance, people who live in a particular neighborhood tend to have similar incomes, drive similar cars, live in similar houses, and have similar habits.

### Other Types of Sampling Techniques

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ sampling, used in quality control, selects sequential units from production lines to ensure the products meet standards set by the manufacturing company.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_ sampling questions a large sample from a large population to determine those qualified to participate. A smaller population of qualified participants is defined and a sample is selected from the group.

Researchers who use a combination of sampling methods are using multistage sampling.

In convenience sampling, the researcher selects subjects who are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. These samples are not chosen randomly and are usually not representative of the population and can lead to biased conclusions.

Conducting a Sample Survey

**Step 1** Decide what information is needed.

**Step 2** Determine how the data will be \_\_\_\_\_\_\_\_\_\_\_ (phone interview, mail

survey, etc.)

**Step 3** \_\_\_\_\_\_\_\_\_\_\_ the information-gathering instrument or \_\_\_\_\_\_\_\_\_ the

questionnaire if one is not available.

**Step 4** Set up a sampling list, if possible.

**Step 5** Select the best \_\_\_\_\_\_\_\_\_\_\_\_\_ for obtaining the sample (random,

systematic, stratified, cluster, or other).

**Step 6** \_\_\_\_\_\_\_\_\_\_\_\_\_ the survey and \_\_\_\_\_\_\_\_\_\_\_\_ the data.

**Step 7** Tabulate the data.

**Step 8** Conduct the statistical \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**Step 9** Report the results.

# 14 – 2. Surveys and Questionnaire Design

## Objective 2. Recognize Faulty Questions On A Survey And Other Factors That Can Bias Responses.

Surveys are often used to collect data. A survey is conducted when a \_\_\_\_\_\_\_\_\_\_\_ of individuals is asked to respond to questions about a particular subject. Interviewer-administered surveys require that a person ask the questions and may be conducted face to face or by telephone. Self-administered surveys may be done by mail, email, or computer or even in a group setting. The way a question is asked can \_\_\_\_\_\_\_\_\_\_\_\_\_ the result.

### Common Mistakes When Writing Questions for a Questionnaire

1. Asking \_\_\_\_\_\_\_\_\_ questions.  
   Biased questions can lead respondents to answer the way the researcher wants them to. People may be less likely to answer a biased question honestly.  
   For example, ask a question “Are you going to vote for XYZ even though the latest survey results show that he will lose the election?” instead of “Are you going to vote for XYZ?” or the more open ended question “Which of the candidates will you vote for?”
2. Using \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ words.  
   The participant may misinterpret the meaning of the words and answer the question in a biased way. A question asking whether one believes people will live longer if they were on a diet is confusing because there are many different types of diets, such as weight-loss, low-salt, gluten-free, etc.
3. Asking \_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_ questions.  
   Questions containing compound sentences ask a participant to answer \_\_\_\_\_\_\_\_ questions at the same time. For example, the question “Do you think all automobiles should have heavy-duty bumpers, even though it will raise the price of cars by $500?” really asks two questions. The first asks whether automobiles should have heavy duty bumpers and the second asks whether the cost of $500 for the heavy duty bumper is reasonable.
4. Using \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_ in questions.  
   Questions using double negatives are confusing. For example, the question “Do you believe it is not safe to not lock the doors of your automobile?” is confusing because “not” is used twice in the sentence. To be clear, ask “Do you believe it is safe to lock the doors of your car?”
5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ questions improperly.  
   The order of the questions asked may lead a participant to respond in a way he or she may not have done otherwise. Researchers can resolve this by ordering the questions differently on different surveys, or by ordering the questions in a way that the answer to one does not affect the answer to a later question.

Other factors that may bias a survey include a participant’s

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ with the topic of the question,
2. belief about what the researcher \_\_\_\_\_\_\_\_\_\_\_ to hear,
3. knowledge of whether his or her \_\_\_\_\_\_\_\_\_\_\_\_ is known or not,
4. feeling at the \_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_ of the survey,
5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to the occurrence of an event such as if the survey is conducted immediately after the occurrence of the event, and
6. response to \_\_\_\_\_\_\_\_\_\_\_\_ versus \_\_\_\_\_\_\_\_\_\_\_\_ questions.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_ questions allow the respondent to provide a variety of answers without having to choose a category, whereas \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ questions force the respondent to choose one of the answers the researcher provides. An example of an open-ended question is “What time of day do you prefer to study?” A closed-ended question is one such as “Which time of day do you prefer to study: morning, noon, afternoon, evening, or late night?

Furthermore, the \_\_\_\_\_\_\_\_\_\_\_\_\_ of the questionnaire should be considered. That is, does each question on a questionnaire meet the objectives of the study. Researchers use pilot studies to test the design and usage of the questionnaire and then rewrite any questions that are misleading, ambiguous, or in some way do not meet the objectives.

# 14 – 3. Simulation Techniques and the Monte Carlo Method

## Objective 3. Solve Problems, Using Simulation Techniques.

Simulation techniques use probability experiments to mimic a real-life situation. Often, studying an actual situation is too \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, so researchers create a similar situation that is less \_\_\_\_\_\_\_\_\_\_\_\_\_ is less \_\_\_\_\_\_\_\_\_\_\_\_\_, and is less \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. For example, chess was invented to simulate warfare. Video games simulate playing real-life sports. Pilots often use simulators to practice flying before they fly the real thing.

Mathematical simulations use probability and random numbers to create conditions \_\_\_\_\_\_\_\_\_\_\_\_ to real-life. The basic simulation technique is called the Monte Carlo method.

### The Monte Carlo Method

The Monte Carlo Method is a simulation technique that uses random numbers. Techniques based on the Monte Carlo Method are used in business and industry to solve problems that have many variables and are very difficult.

### Simulating Experiments Using the Monte Carlo Method

**Step 1** List all possible \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the experiment.

**Step 2** Determine the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of each outcome.

**Step 3** Set up a correspondence between the \_\_\_\_\_\_\_\_\_\_\_\_\_ of the experiment and the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ numbers.

**Step 4** Select \_\_\_\_\_\_\_\_\_\_\_\_ numbers from a table and conduct the experiment.

**Step 5** Compute any \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and state the conclusions.

For example, tossing a coin can be simulated by using random numbers. Since the result of tossing a fair coin is either heads or tails with a probability of , an odd digit can be used to represent tossing a head and an even digit can be used to represent tossing a tail. Thus, tossing a coin 4 times can be simulated by selecting a random number with four digits, such as 8739. This would represent \_\_\_\_\_\_\_\_\_\_\_\_. Alternately, this method could be used to represent the result of tossing four coins.

Rolling a six-sided die can be simulated by using the digits 1, 2, 3, 4, 5, and 6 to represent the number of spots on the face of the die. Digits \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ can be ignored. Rolling two die is represented by a two digits where a 53 represents rolling a five on the first die and a 3 on the second. 83 could not be used since an \_\_\_\_\_\_\_\_\_\_\_\_ cannot be used.

### Example 14-4. Boxing

Boxer A is favored to win over boxer B with odds 4:3. Simulate nine rounds between the two and declare a winner.

*Solution*:

**Step 1** The odds of 4:3 means that Boxer A will win approximately 4 of every 7 rounds while Boxer B will win approximately 3 of every 7 rounds.

**Step 2**  \_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_.

**Step 3** The random digits 1 through 7 can be used to simulate the winner of each round with random digits \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ assigned to a win by Boxer A and random digits \_\_\_\_\_\_\_\_\_\_\_\_ assigned to a win by Boxer B. Digits \_\_\_\_\_\_\_\_\_\_ are ignored.

Technology will be used to generate 9 digits, representing the winner of each round.

**Step 4** For example, nine rounds are fought, and the random number 475457564 is selected. This number means that Boxer A won rounds \_\_\_\_\_\_\_\_\_\_\_\_\_ while Boxer B won rounds \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Round** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **Random numbers** | 4 | 7 | 5 | 4 | 5 | 7 | 5 | 6 | 4 |
| **Winner** |  |  |  |  |  |  |  |  |  |

**Step 5** Boxer \_\_\_\_\_ won this contest.

Repeat this process and declare the winner for your simulation.

### Example 14-5. Playing Basketball

Two basketball players have a free-throw contest. One is a 70% shooter and the other is a 75% shooter. They each shoot 20 shots in groups of 5 shots each. Explain how the experiment can be simulated using technology to simulate the contest and find out who wins.

*Solution*:

**Step 1** One shooter has a probability of of \_\_\_\_\_\_\_\_\_\_\_\_\_\_ the shot and a probability of of \_\_\_\_\_\_\_\_\_\_\_\_\_ the shot.

The second shooter has a probability of of \_\_\_\_\_\_\_\_\_\_\_\_ the shot and a probability of of \_\_\_\_\_\_\_\_\_\_\_ the shot.

**Step 2**  \_\_\_\_\_ and \_\_\_\_\_\_\_.

**Step 3** Using all ten digits, 1, 2, … 9, and 0, to model the first shooter’s free-throws, assign digits \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to the first shooter making the free-throw and assign digits \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to the first shooter missing the free-throw.

Using the digits 1, 2, 3, and 4, Assign digits \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to the second shooter making the free-throw and assign the digit \_\_\_\_ to the second shooter missing the free-throw.

**Step 4** Use technology to simulate results of the first shooter’s first five free-throws by generating five random numbers 1, 2, … 9, 0. The second shooter’s first five free-throw results are obtained by generating five random digits from 1, 2, 3, and 4. Repeat this process three more times to simulate twenty free-throws for each shooter. Determine how many free-throws each shooter made. The winner of the contest is the shooter with the most free-throws made.

An example of the outcomes follows:

| **First shooter (70%) (Digits 1 – 9, 0)** | | **Second shooter (75%) Digits (1 – 4)** | |
| --- | --- | --- | --- |
| **Random numbers** | **# Shots made** | **Random numbers** | **# Shots made** |
| 6 7 8 3 1 |  | 4 3 2 1 4 |  |
| 8 9 2 2 1 |  | 4 1 1 3 4 |  |
| 0 7 0 4 3 |  | 3 2 1 4 1 |  |
| 9 0 8 6 2 |  | 2 1 1 4 2 |  |
| **Total shots made**  **20 shots thrown** |  | **Total shots made**  **20 shots thrown** |  |

**Step 5** The winner is the \_\_\_\_\_\_\_\_\_\_\_\_\_ shooter for this trial of the contest.

The contest can be repeated and the results and winners compared.

### Example 14-6. Selecting a Key

A person selects a key at random from four keys to open a lock. Only one key opens the lock. If the first key does not open the lock, she tries other keys until one opens the lock. Find the average of the number of keys a person will have to try to open the lock. Try the experiment 25 times.

*Solution*:

**Step 1** The outcomes of the experiment are key 1, key 2, key 3 and key 4.

**Step 2** Since a key is selected at random and there are four keys, the probability of selecting each key is .

**Step 3** Assume the keys are number from 1 to 4 and that key 4 opens the lock. The person doesn’t know this, so the keys are selected randomly. For the simulation, select a sequence of random digits using only 1 through 4, until digit 4 occurs.

**Step 4** The trials and random numbers for the 25 trials are shown here.

| **Trial** | **Random digit (key)** | **Number** | **Trial** | **Random digit (key)** | **Number** |
| --- | --- | --- | --- | --- | --- |
| 1  2  3  4  5  6  7  8  9  10  11  12  13 | 134  4  24  324  4  2314  2314  1324  4  4  2314  4  2134 | 3  1  2  3  1  4  4  4  1  1  4  1  4 | 14  15  16  17  18  19  20  21  22  23  24  25 | 4  3124  214  234  3124  3214  24  1324  4  314  234  214  **Total** | 1  4  3  3  4  4  2  4  1  3  3  3  **68** |

**Step 5** Find the mean: . The theoretical average is 2.7. More repetitions should give a result closer to the theoretical average of 2.5.