Chapter 16
Identification Numbers

For All Practical Purposes: Effective Teaching

- Get feedback from students about how much time they are spending on homework. You may wish to give them a guideline such as for each hour of lecture they should think of spending about 2 hours on homework, excluding quiz and exam preparation time.
- Try to look over the exercise set assigned from the previous class session prior to lecture. That way a student is not likely to catch you off guard. Even the most experienced faculty can get caught off guard though. With the nature of the material of this course being so diverse, scanning over the solutions or even keeping copies of solutions on separate paper as part of your lecture notes (don't bring the whole solutions manual to class) can help immensely if you cannot clearly see the path to the solution.

Chapter Briefing

Almost everything we encounter in daily life – consumer goods, credit cards, financial records, people, organizations, mail – is somehow identified or classified by a numeric or alphanumeric code. Of course, this code must unambiguously identify the individual or object it names. But since humans and machines are fallible, the system used for creating the code must be designed to minimize errors. Also, since errors will certainly occur, the system should include a mechanism for detecting and, if possible, correcting the most common errors. In this chapter, you will be mainly examining ways to encode data in the real world along with methods of ensuring that the information is properly encoded/decoded.

Being well prepared for class discussion is essential in order to help students focus on the main topics presented in this chapter. In order to facilitate your preparation, the **Chapter Topics to the Point** has been broken down into **Zip Codes**, **Check Digits**, **Bar Codes**, and **Encoding Personal Data**. Examples with solutions for these topics that do not appear in the text nor study guide are included in the *Teaching Guide*. You should feel free to use these examples in class, if needed.

The last section of this chapter of *The Teaching Guide for the First-Time Instructor* is **Solutions to Student Study Guide ✐ Questions**. These are the complete solutions to the seven questions included in the *Student Study Guide*. Students only have the answers to these questions, not the solutions.

Chapter Topics to the Point

Zip Codes

A type of code that students should be familiar with is the **ZIP code**. The ZIP code is a U. S. Postal Service ID that encodes geographical information about each post office. The first digit in a ZIP code represents one of the ten regions, from east to west, numbered 0–9. Each state is divided into a variable number of smaller geographical areas. The second two digits represent the central mail-distribution point in this area.

ZIP + 4 code is a further refinement of the ZIP code, capable of identifying small groups of mailboxes, like a floor of a building, within a given postal zone.

Teaching Tip

Elicit discussion by asking students about their current zip code and any zip code they may recall. This will start the discussion that they are geographically determined

Check Digits

Many frequently used types of error-detecting code for identification numbers include an extra digit (usually the last digit) called a **check digit**. The check digit can be compared to the rest of the number to check for validity. There are a variety of ways that check digits are determined and verified.

- For a postal service money order, the check digit (the last digit) is the remainder you get when you divide the sum of the other digits by 9.
- Some mail (UPS) and car rental services use as an extra check digit as the remainder when you divide the number by 7.
- The ***Universal Product Code*** (***UPC***) is a twelve-digit code, $a_1a_2a_3a_4a_5a_6a_7a_8a_9a_{10}a_{11}a_{12}$, including a check digit at the end. By adding the digits and multiplying by their weight (alternately 1 for even positions, 3 for odd positions), the sum must be a number ending in 0.
- The **Codabar** system is a variation of UPC using a similar sum with weights 2 (odd positions) and 1 (even positions). To this sum, you add the number of digits in odd positions that exceed 4; the resulting number must end in 0 to be a valid Codabar code.
- A **ZIP + 4 number** is made up of 9 digits and one check digit. Including a check digit at the end, the sum of the ZIP + 4 digits must be a number ending in 0.

Another important and effective error-detecting code is the **International Standard Book Number** (**ISBN**). It is a 10-digit code, $a_1a_2a_3a_4a_5a_6a_7a_8a_9a_{10}$. It has the following property.

$10a_1 + 9a_2 + 8a_3 + 7a_4 + 6a_5 + 5a_6 + 4a_7 + 3a_8 + 2a_9 + a_{10}$ is evenly divisible by 11.

Teaching Tip

With the different methods of determining check-digits for various companies and organizations, you may find it helpful to summarize the methods in a table.

Example

Explain why the ISBN of this *Guide* is valid.

Solution

The ISBN of this manual is 0-7167-0128-6. Using the algorithm we have the following.

$$10\cdot 0+9\cdot 7+8\cdot 1+7\cdot 6+6\cdot 7+5\cdot 0+4\cdot 1+3\cdot 2+2\cdot 8+6=187$$

Since 187 is divisible by 11 ($11\cdot 17=187$), this is a valid ISBN.

Example
Explain why the fictitious credit card number 4019 2783 1111 2322 a not a valid number using Codabar?

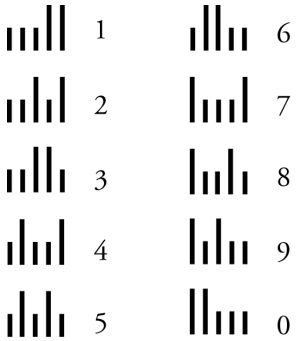
Solution
The numbers in the odd positions are 4_1_ 2_8_ 1_1_ 2_2_. The numbers in the even positions are _0_9 _7_3 _1_1 _3_2 (the last position is the check digit). The number that exceeds 4 in an odd position is _ _ _ _ _ _8_ _ _ _ _ _ _ _ _.
The Codabar algorithm yields the following.

$$(4+1+2+8+1+1+2+2)\times 2+1+(0+9+7+3+1+1+3+2)=69$$

Since this number does not end in zero (69), the credit card is not a valid number using the Codabar algorithm.

Bar Codes
Bar codes use light spaces and dark bars to represent a two-symbol binary code that is easily scanned optically and decoded by a computer.

ZIP code bar codes use the **postnet code**. Each digit is represented by a group of five dark bars, two long and three short. At the beginning and end there are two long bars, which are called guard bars. The following are the bar patterns.



Teaching Tip
Have students closely examine the code for each of the digits and notice patterns in the bars. You may choose to bring in a piece of mail to verify the bar coding or ask each student to as well.

The **UPC** (**Universal Product Code**) is a familiar sight on labels for retail products. Digits are represented by sequences of light and dark bars, where adjacent dark bars blend together to make bars of different widths. In this way, seven bar spaces ("modules") produce two light and two dark bars for each digit. There are different binary coding patterns for manufacturer numbers and product numbers. Refer to Table 16.1, page 608 of the textbook.

Encoding Personal Data

Personal data such as your name, birthdate, or sex can be encoded different ways. One way to encode a surname (last name) is the **Soundex Coding System**. The procedure is as follows.

1. Delete all occurrences of *h* and *w*.
2. Assign numbers to the remaining letters as follows:
$$a, e, i, o, u, y \rightarrow 0;\ b, f, p, v \rightarrow 1$$
$$c, g, j, k, q, s, x, z \rightarrow 2;\ d, t \rightarrow 3$$
$$l \rightarrow 4;\ m, n \rightarrow 5;\ r \rightarrow 6$$
3. If two or more letters with the same numeric value are adjacent, omit all but the first.
4. Delete the first character of the original name if still present.
5. Delete all occurrences of *a*, *e*, *i*, *o*, *u*, and *y*.
6. Retain only the first three digits corresponding to the remaining letters; append trailing 0's if fewer than three letters remain; precede the three digits obtained in step 6 with the first letter of the surname.

Example
Encode the surname *Adams* using the Soundex Coding System.

Solution

	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	
Adams	→ Adams	→ Adams 03052	→ Adams 03052	→ dams 3052	→ dms 352	→	A-352

The surname Adams is encoded as A-352.

Teaching Tip
If you have a small class, have students encode their surnames and submit them to you. Write all the encoded names on the board and see if they can determine which belongs to each of the students. This will help students interact with each other and build their logic skills.

Driver's licenses contain encoded information. For example, Florida and Illinois driver's licenses use an encoding system that considers both the date of birth and the sex of the resident.

- Florida: A five-digit number contains the information for the resident. The first two digits are the birth year (without the 19), followed by a dash. Each day of the year is assigned a three-digit number with 001 representing January 1. Each month is assigned 40 days. Added to this number is 500 if the resident is female.
- Illinois: A five-digit number contains the information for the resident. The first two digits (separated by a dash) are the birth year (without the 19). Each day of the year is assigned a three-digit number with 001 representing January 1. Each month is assigned 31 days. Added to this number is 600 if the resident is female.

Example
What would be the five-digit number assigned to a female driver in the states of Florida and Illinois born on July 27, 1966?

Solution
Florida: July 27 corresponds to $6 \cdot 40 + 27 = 267$. Add to this 500 for female to obtain 767. Since the birth year is 1966, the five-digit number would be 66-767.

Illinois: July 27 corresponds to $6 \cdot 31 + 27 = 213$. Add to this 600 for female to obtain 813. Since the birth year is 1966, the five-digit number would be 6-6813.

Solutions to Student Study Guide ✎ Questions

Question 1
If the ID number of a FedEx package is 3213213213X, what is the value of X?

Solution
If you divide 3213213213 by 7, you get 459030459 with a remainder of 0. Thus, X = 0.

Question 2
If the UPC code for a product is 12345678901X, what is the value of X?

Solution
Since $3\cdot1+2+3\cdot3+4+3\cdot5+6+3\cdot7+8+3\cdot9+0+3\cdot1=98,$ the last digit (check digit) must be 2 in order to have a sum that ends in 0.

Question 3
What is the missing digit of the fictitious credit card number 1234 5678 X234 5678 using Codabar?

Solution
The numbers in the odd positions are 1_3_ 5_7_ X_3_ 5_7_. The numbers in the even positions are _2_4 _6_8 _2_4 _6_8 (the last position is the check digit). The numbers that exceed 4 in odd positions are _ _ _ _ 5_7_ _ _ _ _ _ 5_7_or _ _ _ _ 5_7_ X_ _ _ 5_7_.
First, assume that X has a value of 4 or less.
The Codabar algorithm yields the following.

$$\begin{aligned}(1+3+5+7+X+3+5+7)\times2+4+(2+4+6+8+2+4+6+8) &= (31+X)\times2+4+40\\ &= 62+2X+44\\ &= 106+2X\end{aligned}$$

If X is to be 0, 1, 2, 3, or 4 then the only value that will allow $106+2X$ to end in 0, would be 2.

Next assume that X has a value of 5 or more.

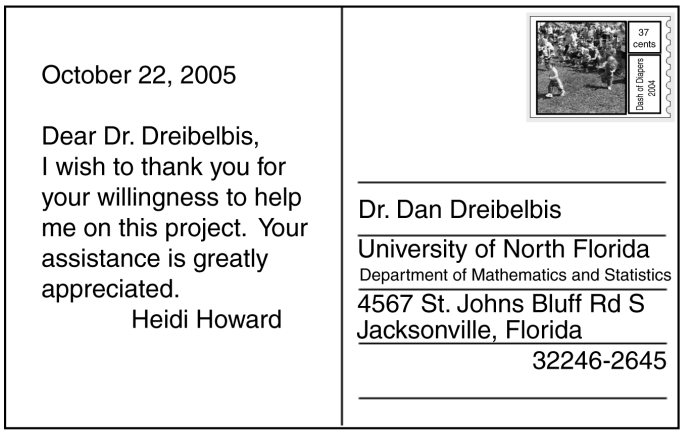
The Codabar algorithm yields the following.

$$\begin{aligned}(1+3+5+7+X+3+5+7)\times2+5+(2+4+6+8+2+4+6+8) &= (31+X)\times2+5+40\\ &= 62+2X+45\\ &= 107+2X\end{aligned}$$

If X is to be 5, 6, 7, 8, or 9 then $107+2X$ cannot end in 0.
Thus, the only possible value of X is 2.

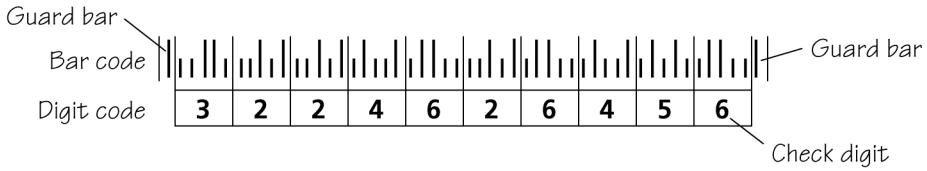
Question 4

Render a drawing of what the bar code would look like for the following postcard, including the check digit for the ZIP+4 number. What would the check digit be for the postcard?



Solution

The sum of the ZIP+4 digits is $3+2+2+4+6+2+6+4+5=34$. In order for the sum of the ZIP+4 and the check digit to end in 0, the check digit must be 6. The bar code would look as follows.



Question 5

How would the surname *Hochwald* be encoded using the Soundex Coding System?

Solution

Step 1		Step 2		Step 3		Step 4		Step 5		Step 6		
Hochwald	→	ocald	→	ocald 02043	→	ocald 02043	→	ocald 02043	→	cld 243	→	H-243

Question 6

53-640 identifies a Florida driver of which sex and birth date?

Solution

The 53 indicates the birth year 1953. Since 640 exceeds 500, we know that the individual is female. Subtracting 500 from 640, we obtain 140. Dividing 140 by 40, we obtain 3 with a remainder of 20. This implies the birthday is on the 20th day of the fourth month. Thus, the individual is a female born on April 20, 1953.

Question 7

5-3640 identifies an Illinois driver of which sex and birth date?

Solution

The 5-3 indicates the birth year 1953. Since 640 exceeds 600, we know that the individual is female. Subtracting 600 from 640, we obtain 40. Dividing 40 by 31, we obtain 1 with a remainder of 9. This implies the birthday is on the 9th day of the second month. Thus, the individual is a female born on February 9, 1953.