CHAPTER 16: IDENTIFICATION NUMBERS

Recognize any of these?

979-845-3261 77843-3368

876-87-6543 978-0-495-83538-7

16.1 Check Digits

Identification numbers may or may not have information coded in.

Identification numbers are subject to errors.

Consider your exam score as a two digit number a_1a_2.

What if a score of 75 was entered as 65? Or as a 57? Add a ***check digit*** to catch some types of errors.

Exam score is entered as $a_1a_2a_3$ where $a_3 = a_1 + a_2 \bmod 10$

EXAMPLE
Find the check digit $a_3 = a_1 + a_2 \pmod{10}$ for the following exam scores:

75

65

57

More about modular arithmetic

EXAMPLE

(a) If today is Tuesday, what day of the week is it in 23 days?

(b) If it is 7A, what time is it in 15 hours?

Definition: Congruence Modulo m

Let *a*, *b*, and *m* be integers with $m \geq 2$. Then *a* is congruent to *b* modulo *m*, written

$$a \equiv b \bmod m$$

means that *m* evenly divides $a - b$.

EXAMPLE

Determine if each of the congruences below are true or false.

(a) $24 \equiv 0 \bmod 3$

(b) $21 \equiv 1 \bmod 5$

(c) $27 \equiv 5 \bmod 11$

(d) $21 \equiv 1 \bmod 7$

EXAMPLE

Find the following values

(a) 99 mod 11 is

(b) 12 mod 7 is

(c) 27 mod 8 is

(d) 40 mod 13 is

Types of errors when dealing with identification numbers:

- Replacing one digit with a different digit (single digit error)
  - *ac* entered rather than *ab*
- Transposing two adjacent digits (adjacent transposition error)
  - *ba* entered rather than *ab*
- Transposing a sequence of digits (jump transposition error)
  - *cba* entered rather than *abc*

We found that using the check digit $a_3 = a_1 + a_2 \pmod{10}$ for exam scores did not detect transposition errors. Would using a different mod number help?

You can assign a ***weight*** to digits in a code. That is, multiply one or more of the digits in a code by an integer.

EXAMPLE

Using the check digit $a_3 = 2a_1 + a_2 \bmod 10$, determine if the following exam scores are valid

(a) 759

(b) 657

(c) 577

(d) 679

(e) 179

What is the problem here?

EXAMPLE

Will the check digit $a_3 = 3a_1 + a_2 \bmod 10$ catch single digit errors and adjacent transposition errors? What if we did mod 11?

Some check digit methods

- US Postal Service Money order: $a_1a_2a_3a_4a_5a_6a_7a_8a_9a_{10}a_{11}$. The check digit is
  $a_{11} = a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_9 + a_{10} \bmod 9$
- American Express and Visa traveler's checks along with Euro banknotes have a check digit that is chosen to make the sum of all the digits evenly divisible by 9.
- UPC: $a_1a_2a_3a_4a_5a_6a_7a_8a_9a_{10}a_{11}a_{12}$ has a_{12} chosen so that the sum $3(a_1 + a_3 + a_5 + a_7 + a_9 + a_{11}) + 1(a_2 + a_4 + a_6 + a_8 + a_{10})$ is divisible by 10.
- ISBN – see your textbook
- Bank routing numbers have 8 digits and a check digit at the end, $a_1a_2a_3a_4a_5a_6a_7a_8a_9$. The check digit a_9 is the last digit of the sum $9(a_3 + a_6) + 7(a_1 + a_4 + a_7) + 3(a_2 + a_5 + a_8)$

EXAMPLE

(a) Determine the check digit for a US Postal Service Money order with identification number 7234541780.

(b) Determine the check digit for the bank routing number 09100001.

EXAMPLE

Suppose a check digit is assigned to a 4 digit number by appending the sum of the 4 digits mod 7 to the end. If the number 96802 has a single digit error, but the check digit is correct, what might the correct number?

Credit Cards

A 15 digit number with a 16^{th} number as the check digit,
$a_1a_2a_3a_4\ a_5a_6a_7a_8\ a_9a_{10}a_{11}a_{12}\ a_{13}a_{14}a_{15}a_{16}$

The check digit is found by adding all the numbers in the odd positions and doubling that,

$$s_1 = 2\left(a_1 + a_3 + a_5 + a_7 + a_9 + a_{11} + a_{13} + a_{15}\right)$$

Then count the number of digits in the odd positions that are over 4 and call this s_2.

Next, find the sum of the numbers in the even positions,

$$s_3 = a_2 + a_4 + a_6 + a_8 + a_{10} + a_{12} + a_{14}$$

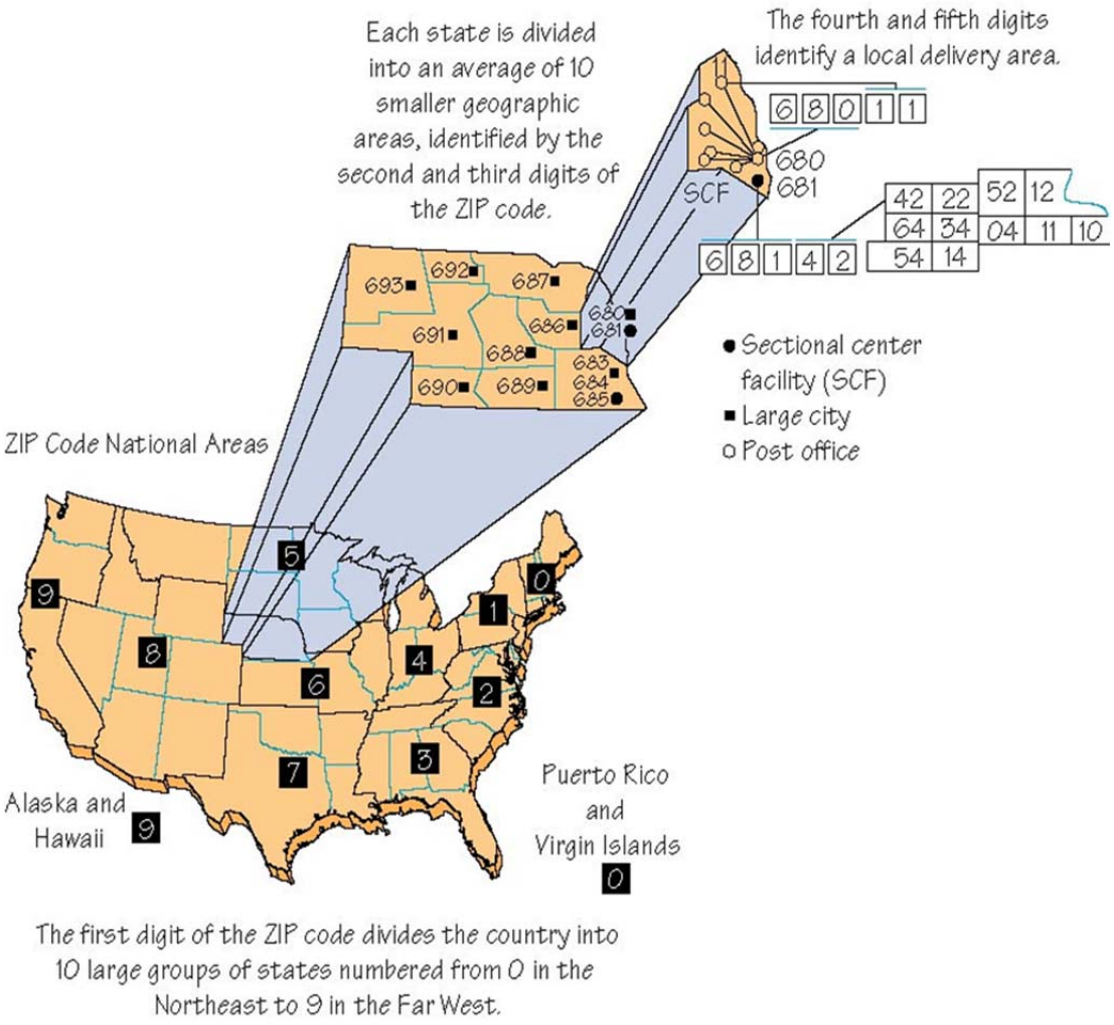
The check digit a_{16} is the number needed to bring the total of the three sums above to a multiple of 10.

EXAMPLE

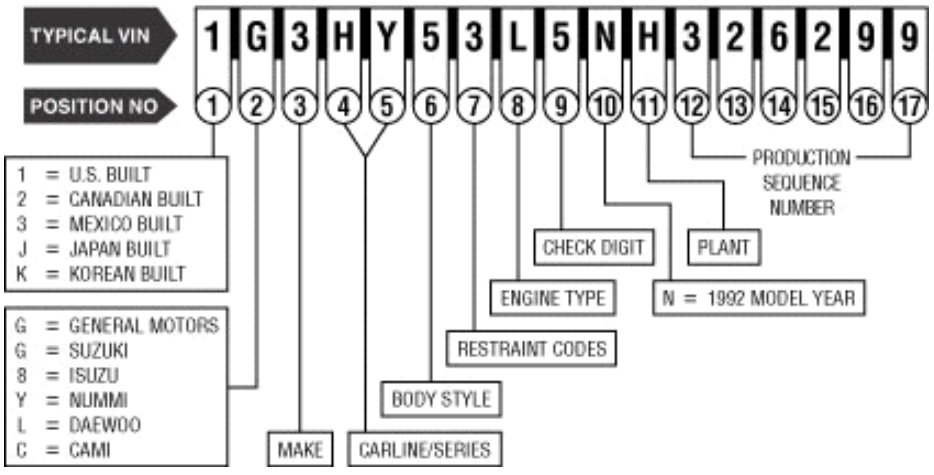
(a) Is 4128 0012 3456 7890 a valid credit card number?

(b) Suppose that a credit card number is 4264 5200 2177 *x*337. What is the value of *x*?

16.2 The Zip Code (and Other Codes with information)



VIN codes are Vehicle Identification Codes.



UPC is a universal product code.

First digit	Type of item
0	General groceries
2	Items sold by weight
5	Coupons

Next 5 digits are for the manufacturer, then 5 digits for the product number. The last digit is the check digit.

16.3 Bar Codes

A ***bar code*** is a series of dark bars and light spaces that represent characters.

Any system for representing data with only two symbols is ***a binary code***.

The ***postnet*** code is used to encode ZIP + 4 numbers by assigning the 10 digits to bar codes that have 5 vertical bars (2 long and 3 short).

There are 52 vertical bars needed. The first and last bars are *guard bars* to mark the beginning and end of the code. The 50 remaining bars give 10 digits. The first 9 of which are the ZIP + 4 and the last one is a check digit.

The postnet check digit is determined by adding the first 9 digits and making the 10th digit have the sum come to a multiple of 10.

The ***delivery-point*** barcode allows for two more digits so that the mail can be sorted in the order that it will be delivered from the carrier.

The ***intelligent mail*** barcode uses 65 vertical bars to convert 31 digits of data. The bars have 3 lengths and can be in different vertical positions. The data encoded has the type of service, the mail owner, a unique tracking number and delivery zip.

ribbs.usps.gov/onecodesolution/

QR (Quick Response) codes

These can encode much more information and are popular in print media. The Cooking Light magazine from September, 2011 had quite a few, including

16.4 Encoding Personal Data

In Florida, the last three digits of the driver's license number of a female with birth month *m* and birth date *b* are $40(m-1)+b+500$.

In Florida, the last three digits of the driver's license number of a male with birth month *m* and birth date *b* are $40(m-1)+b$.

For both males and female in Florida the 4^{th} and 5^{th} digits from the end of the driver's license number give the year of birth.

EXAMPLE
Determine the last 5 digits of a Florida driver's license number for the following people

(a) A female born on July 18, 1942

(b) A male born on May 1, 1988

(c) What do you know about a person who has 61528 as the last 4 digits of their FL driver's license?

(d) What about 34475?