CHAPTER 4

Number Representation and Calculation



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4.2

Number Bases in Positional Systems

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Objectives

- 1. Change numerals in bases other than ten to base ten.
- 2. Change base ten numerals to numerals in other bases.

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Changing Numerals in Bases Other Than Ten to Base Ten

The base of a positional numeration system refers to the number whose powers define the place values.

The place values in a base five system are powers of five:

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Changing to Base Ten

To change a numeral in a base other than ten to a base ten numeral,

- 1. Find the place value for each digit in the numeral.
- 2. Multiply each digit in the numeral by its respective place value.
- 3. Find the sum of the products in step 2.

Example: Converting to Base Ten

Convert 4726_{eight} to base ten.

Solution: The given base eight numeral has four places. From left to right, the place values are 8^3 , 8^2 , 8^1 , and 1

Find the place value for each digit in the numeral:



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Example continued

Multiply each digit in the numeral by its respective place value.

$$4726_{\text{eight}} = (4 \times 8^{3}) + (7 \times 8^{2}) + (2 \times 8^{1}) + (6 \times 1)$$
$$= (4 \times 8 \times 8 \times 8) + (7 \times 8 \times 8) + (2 \times 8) + (6 \times 1)$$
$$= 2048 + 448 + 16 + 6$$
$$= 2518$$

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Changing Base Ten Numerals to Numerals in Other Bases

We use division to determine how many groups of each place value are contained in a base ten numeral.

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Example: Using Division to Convert from Base Ten to Base Eight

Convert the base ten numeral 299 to a base eight numeral.

Solution: The place values in base eight are $..., 8^3, 8^2, 8^1, 1$, or ..., 512, 64, 8, 1.

The place values that are *less* than 299 are 64, 8, and 1. We use division to show how many groups of each of these place values are contained in 288.

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Example continued



These divisions show that 299 can be expressed as 4 groups of 64, 5 groups of 8 and 3 ones:

$$299 = (4 \times 64) + (5 \times 8) + (3 \times 1)$$
$$= (4 \times 8^{2}) + (5 \times 8^{1}) + (3 \times 1)$$
$$= 453_{\text{eight}}.$$

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Example: Using Divisions to Convert from Base Ten to Base Six

Convert the base ten numeral 3444 to a base six numeral.

Solution: The place values in base six are

 $\dots 6^5$, 6^4 , 6^3 , 6^2 , 6^1 , 1, or $\dots 7776$, 1296, 216, 36, 6, 1.

We use the powers of 6 that are *less* than 3444 and perform successive divisions by these powers.



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Example continued

Using these four quotients and the final remainder, we can immediately write the answer.

 $3444 = 23540_{six}$

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