# 1.4 General number bases

#### **Bases**

Numbers can use nearly any base, such as base 5 or base 17. Popular bases are:

- 2: Binary, due to computers using 0's and 1's
- 8: Octal, which can compactly represent binary (each octal digit represents three bits)
- 16: Hexadecimal (hex), which can compactly represent binary (each hex digit represents four bits).
- 10: Decimal, due to humans having ten fingers.

When a number's base is unclear, the base is written as a subscript, as in  $930_{15}$ .

Each digit in a base B is weighted by a power of B, as below. Each digit can be 0 to B - 1.

Figure 1.4.1: Each digit in a base B is weighted by a power of B.

$$\frac{V}{B^3}$$
  $\frac{W}{B^2}$   $\frac{y}{B^1}$   $\frac{z}{B^0}$ 

$$v \times B^3 + w \times B^2 + y \times B^1 + z \times B^0$$

PARTICIPATION ACTIVITY

1.4.1: General bases.

1) For base 5, what are the possible values for each digit?

- O 0 to 4
- O 0 to 5
- 2) 104 base 5 is \_\_\_\_\_ in decimal.
  - **O** 29
  - **O** 135
- 3) 128 is a valid base 8 number.
  - O True
  - O False

## From any base to decimal

Converting from any base to decimal is straightforward: Each digit's decimal value is multiplied by each digit's decimal weigneed.

 PARTICIPATION ACTIVITY
 1.4.2: Various bases to decimal tool: Try selecting different bases.

 Base-2
 ▼
 Reset

 0
 0
 0
 0
 0
 0

 2<sup>7</sup>
 2<sup>6</sup>
 2<sup>5</sup>
 2<sup>4</sup>
 2<sup>3</sup>
 2<sup>2</sup>
 2<sup>1</sup>
 2<sup>0</sup>

 128
 64
 32
 16
 8
 4
 2
 1

 0 · 128
 +
 0 · 64
 +
 0 · 32
 +
 0 · 16
 +
 0 · 8
 +
 0 · 4
 +
 0 · 1
 =
 0

 (decimal \tag{decimal \tag{d

1.4.3: General bases to decimal.

1) What is 111 base 5 in decimal?

O 31
O 111

2) What is 200 base 30 in decimal?

O 60
O 1800

### From decimal to any base

Converting from decimal to any base can be done using a simple algorithm. The decimal is divided by the base, and remair rightmost digit. The process repeats with the quotient and the next digit, until the quotient is 0.

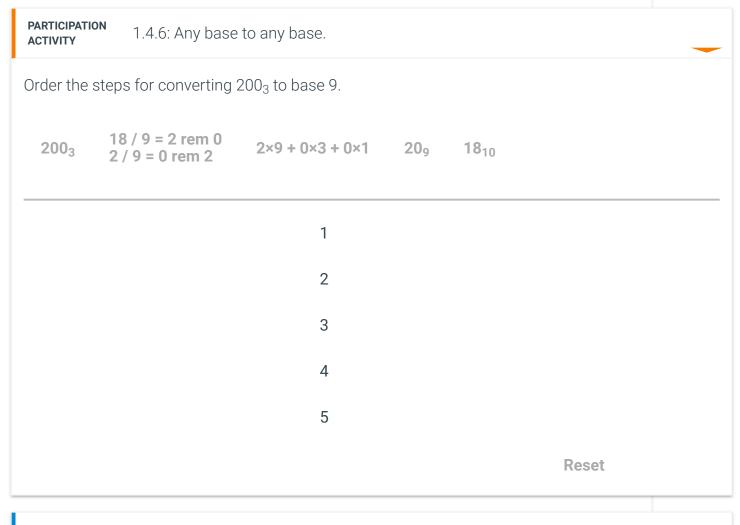
**PARTICIPATION** 1.4.4: Converting from decimal to any base. **ACTIVITY** Start 2x speed 2B3<sub>15</sub>  $= 2 \times 15^{2} + 11 \times 15^{1} + 3 \times 15^{0}$ Any base to decimal = 450 + 165 + 3= 618 <sub>10</sub> 73<sub>10</sub> 14  $2 \times 5^{2} + 4 \times 5^{1} + 3 \times 5^{0}$ Decimal to = 50 + 20 + 3/5 /5 / 5 = 73 any base 0 rem 2 2 rem 4 14 rem 3 243<sub>5</sub>

PARTICIPATION ACTIVITY 1.4.5: Converting decimal to/from other bases.	_
1) What is 34 base 6 in decimal?	_
Check Show answer	
2) What is 102 base 3 in decimal?	_
Check Show answer	
3) When converting 29 decimal to base 3, what is the rightmost digit in base 3?	•
what is the right most digit in base 3:	
Check Show answer	
4) When converting 29 decimal to base 3,	_
29 / 3 yields quotient 9. What is the second digit in base 3?	
Check Show answer	
5) What is 29 decimal in base 3?	_

**Check** Show answer

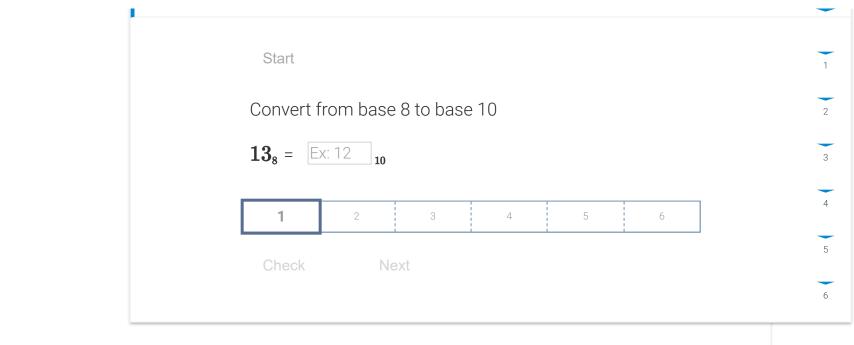
#### Any base to any base

To convert a number in any base B directly to any other base C, a straightforward approach first converts the base B numb number, then converts that decimal number to base C. Ex: To convert  $320_5$  to base 8, one starts with  $320_5 = 3 \times 25 + 2 \times 5 = 8$  converting to base 8: 85/8 = 10 remainder 5, 10/8 = 1 remainder 2, 1/8 = 0 remainder 1, so concatenating yields  $125_8$ .



CHALLENGE ACTIVITY

1.4.1: Converting between bases.



Provide feedback on this section