Name: _____   Date: _____

Student Exploration: Number Systems

Vocabulary: base-10, binary system, digit, place value

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)
An odometer, like the one shown to the right, shows a car's mileage.
When a car is new, every digit of the odometer is a zero: 000,000
miles. (Each individual numeral, 0 through 9, that makes up a
number is called a **digit**.)

1. Most odometers display 6 digits. Suppose you notice that every digit on your odometer is a
   zero, except for one of them, which is a 1. What could the mileage of your car be? Explain.

   _____

   _____

2. Suppose the six digits on your odometer are three 0's, a 2, a 3, and an 8. If the mileage is

   less than 1000, what is the largest it could be? _____   The smallest? _____
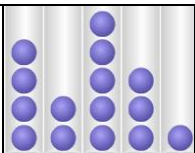
Gizmo Warm-up
Numbers, like mileage on an odometer, can have the same digits but very
different values. This is because the value of a digit depends on its **place
value**. In a **base-10 system** like we use, place values are powers of 10 such
as ones (10^0), tens (10^1), hundreds (10^2), etc. In the *Number Systems* Gizmo,
you can model numbers with beads to help explore place value. You can also
experiment with other number systems, like binary (base-2).
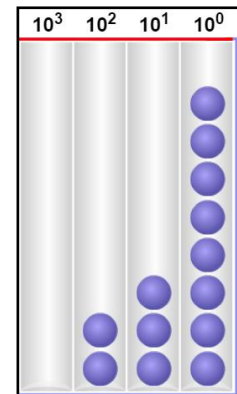
Drag the **Base** and the **Base-10 value** sliders to vary the values. You can
also drag one bead at a time into a column. To enter a specific value, click in
the text field, type the value, and hit **Enter**.

1. In the Gizmo, set the **Base-10 value** to 238. Be sure the **Base** is 10.

   A. How many beads are in each column? 10^3: _____ 10^2: _____ 10^1: _____ 10^0: _____

   B. Which column corresponds to the ones digit? _____

2. Click **Clear**. What is the smallest number you can model with one bead? _____

   What is the largest number you can model with just one bead? _____

| **Activity A:**

Exploring base-10 | <u>Get the Gizmo ready</u>:

• Click the **Clear** button.
• Be sure that the **Base** is set to 10. | |

1. In the Gizmo, drag a bead from the bin and place it in the 10^2 column.

    A. When one bead is in the 10^2 column what is the value? _____

    B. Move the bead one column to the right (to 10^1). What is the new value? _____

    C. Move the bead one column to the right (to 10^0). What is the new value? _____

    D. As the bead moves one place value to the right, how does the value change? _____

    _____

    E. What is the value of 10^0? _____

2. Without the Gizmo, consider the base-10 number 427.

    A. If you modeled 427, how many beads would be in each column?

        10^2: _____ 10^1: _____ 10^0: _____

    B. In the Gizmo, set the **Base-10 value** to 427. Click **Show expanded form**. Using exponents, express the number 427 in expanded form.

    _____

    C. In the number 427, 4 is in the "hundreds place," 2 is in the "tens place," and 7 is in the "ones place." Look at the expanded form and explain why that makes sense.

    _____

    _____

    D. Drag a new bead from the bin on the right to the tens place (10^1 column). How does

    this change the number modeled? _____

    E. What number will be modeled if a new bead is placed in the 10^4 column? Explain your answer. Then try it in the Gizmo.

    _____

    _____

(Activity A continued on next page)

Activity A (continued from previous page)

3. Click **Clear**. Then model the number 350 by dragging beads into the columns.

    A. How many beads are in each column? 10^3: _____ 10^2: _____ 10^1: _____ 10^0: _____

    B. Express 350 in expanded form. _____

    C. How many beads did you use, total? _____

    D. What is the sum of the digits in the number 350? _____

4. Click **Clear**. Using the beads, model the number 23,062.

    A. How many beads did you place in each column?

       10^5: _____ 10^4: _____ 10^3: _____ 10^2: _____ 10^1: _____ 10^0: _____

    B. On the line below, express 23,062 in expanded form.

       _____

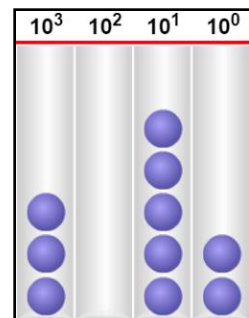   Check your answer in the Gizmo.

5. The beads in the chart on the right model a number in base-10.

    A. How many beads are in each column?

       10^3: _____ 10^2: _____ 10^1: _____ 10^0: _____

    B. What number is modeled? _____

    C. Express the number in expanded form.

       _____

       Check your answer in the Gizmo.

6. In the Gizmo, click **Clear**. Then experiment with modeling numbers using 10 beads total.

    A. What is the largest number that can be modeled using 10 beads? _____

       Explain. _____

    B. What is the smallest number that can be modeled using 10 beads? _____

       Explain. _____

| Activity B: **Exploring the binary system**	Get the Gizmo ready: • Click the **Clear** button. • Select **Show expanded form**.	

The **binary system**, a base-2 number system, is widely used by computers. The only digits in a binary number are 0 and 1. A number in binary is written with a subscript of 2, like this: 101_2.

1. In the Gizmo, set the **Base** to 2. Drag one bead to the rightmost column.

    A. What base-2 (binary) number is modeled? _____

    B. What is the base-10 equivalent of this binary number? _____

    C. Now add a new bead, in the 2^1 column. What binary number is modeled? _____

    D. Write the number in expanded form. _____

    E. What is the base-10 equivalent of this new binary number? _____
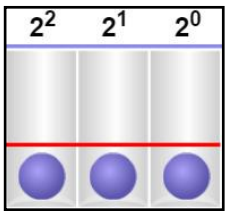
    Check your answers in the Gizmo.

2. A binary number is modeled to the right.
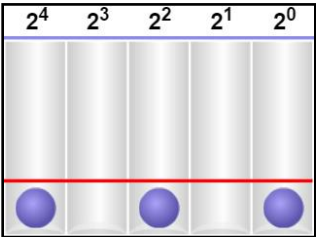
    A. What binary number is modeled? _____

    B. Write the number in expanded form.

    _____

    C. What is the equivalent base-10 value? _____ Check your answers in the Gizmo.

    D. What are the place values of a five-digit binary number? Explain your answer.

    _____

    _____

3. In the Gizmo, use beads to model the binary numbers 111_2 and 1000_2.

    A. What is the base-10 value of 111_2? _____ 1000_2? _____

    B. You should have found that the values of 111_2 and 1000_2 are only one apart. Explain why this makes sense.

    _____

    _____