ACTIVITY 3

FOLLOW THE ARROW

In Unit 1, *Pick a Winner: Decision Making in a Democracy*, you learned that it can be easier to solve a problem in one representation than in another. The same is true of coding, decoding, and code cracking. To be good at all three, you must know a variety of ways to represent a coding process.

In this activity, you use tables, graphs, and a representation called an **arrow diagram** to analyze and communicate coding processes.

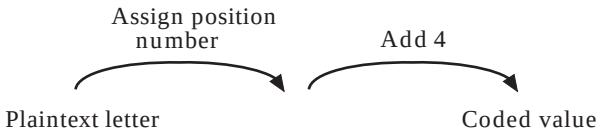

Figure 2.7.
Shift +4 arrow diagram.

1. The arrow diagram in **Figure 2.7** represents a coding process.

   a) Describe the coding process.

   b) Draw a new arrow diagram representing the same process, but with letters coded as letters.

   c) Use an arrow diagram to represent a shift of +3 followed by a shift of +7. Copy **Figure 2.8** onto your paper and write the description of each step above its arrow.

Figure 2.8.
A three-step arrow diagram.

   d) What are some advantages of this representation? That is, would the coder, decoder, or code breaker find it useful?

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Mathematicians use the term **function** to describe a process that transforms items such as letters or numbers into other letters or numbers uniquely. When a message is coded, a plaintext letter or position number is matched with a unique new coded value or letter.

A function produces a single output from an input. In the context of codes, the coded value is the output that results when the coding process is applied to the original position number (the input). In the context of a business, the input may be the number of items sold and the output may be the total profit.

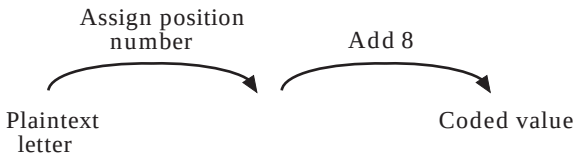

Figure 2.9.
An arrow diagram for a coding process.

An arrow diagram is a good way to show the steps of a process like a function. A table is another way to represent a function. A table lists some or all of the matched pairs of inputs and outputs.

2. The arrow diagram in **Figure 2.9** represents a shift coding process.

Plaintext letter	A	B	C	D	E	F	G	H	I	J	K	L	M
Original position													
Coded value													
Plaintext letter	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Original position													
Coded value													

Figure 2.10.

a) Use the arrow diagram in Figure 2.9 to complete the table in **Figure 2.10.**

b) What are some advantages of this representation? That is, would the coder, decoder, or code breaker find it useful?

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A **coordinate graph** is another way to represent a coding process. A coordinate graph is based on two lines that intersect at right angles. Each line is called an **axis**. In this unit, the horizontal axis usually represents the plaintext letter or its position number. In general, the horizontal axis is associated with a function's input. The vertical axis represents the coded value or, sometimes, the coded letter. In general, the vertical axis is associated with a function's output. The place where the two axes intersect is called the **origin** (see **Figure 2.11**).

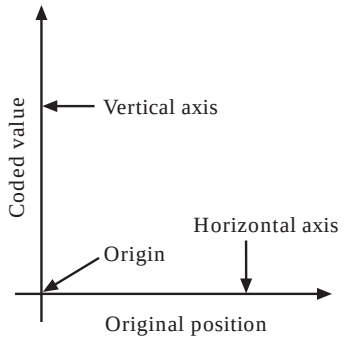

Figure 2.11.
A coordinate graph for coding.

Every location or point on a graph is identified with a pair of numbers called **coordinates**. The numbers in each pair are ordered so the first number represents horizontal position on the graph and the second number represents vertical position on the graph. For example, the point with coordinates (5, 8) identifies the point on the graph with a horizontal position of 5 and a vertical position of 8 (see **Figure 2.12**). In the context of codes, the point with coordinates (5, 8) means the letter with original position of 5 (the input) is matched with the coded value of 8 (the output).

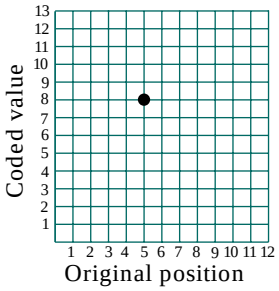

Figure 2.12.
The graph of (5, 8).

Graphs should always have a title or brief description, each axis should be numbered with a consistent scale, and each axis should have a label or description. Note that in Figure 2.12 the brief description is "The graph of (5, 8)," both axes are numbered with scales of one, the vertical axis is labeled "Coded value," and the horizontal axis is labeled "Original position."

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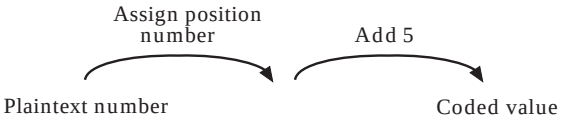

Figure 2.13.

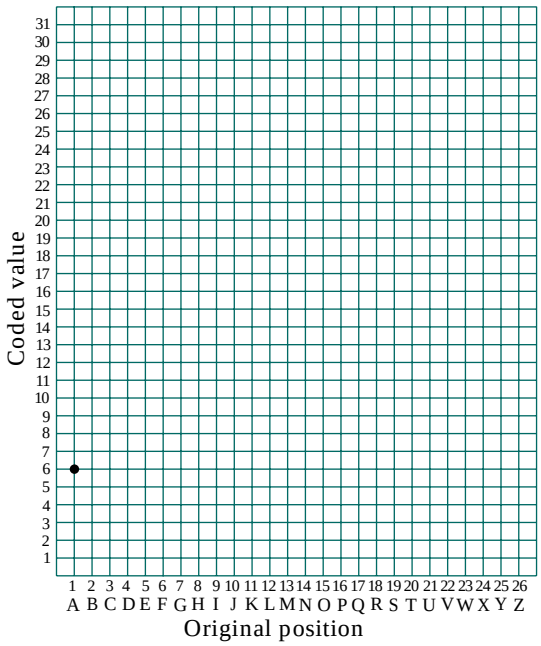

Figure 2.14.
Graph of coded value versus original position.

3. The arrow diagram in **Figure 2.13** represents a coding process.

   a) Use a sheet of graph or dot paper (as in **Figure 2.14**) to graph the coding process.

   b) Describe your graph.

   c) How is the graph different if you shift eight instead of five?

   d) What are some advantages of this representation? That is, would the coder, decoder, or code breaker find it useful?

4. If you want a friend to decode your messages, you must communicate the coding process. You can use an arrow diagram, a table, or a graph to communicate the coding process. Which representation would you choose? Why?

People who exchange coded messages must tell each other how they are coding so the recipient of the message can decode it. Communicating the method is the classic problem of secret codes. Telling someone you are coding by "adding 3" requires brief communication; telling someone an entire table requires a larger communication.

Machines like computers are frequently used as aids by people who code and decode. Computers and calculators work more easily with numbers than with letters.

Symbolic forms, which are the topic of Activity 4, are required by many computers and graphing calculators. Symbolic forms allow the calculator to do much of the tedious and repetitious work. Another advantage of symbolic forms is they are easy to change. Coders often change their process to foil code crackers. Dictionary coding systems are hard to change because it requires writing an entire dictionary that must be transmitted to all parties using the system.