NUMB3RS Activity: Numb3rs of the I Ching
Episode: "Undercurrents"

Topic: counting, symbolism, and encoding   **Grade Level:** 6 - 12
Objective: To understand the properties of the structure of the **I Ching** symbols.
Time: 10 minutes

Introduction

The **I Ching** ("Book of Changes" or "Classic of Changes") is the oldest of the classic Chinese texts, believed by many to be nearly 5,000 years old. The I Ching is based upon a philosophy that lies at the heart of Chinese culture. Given its history and impact on cultures worldwide over several centuries, it is not the purpose of this activity to explore the text's philosophy. In this activity, students will understand how the symbols, called *hexagrams*, are constructed, and how they are related to the *NUMB3RS* episode "Undercurrents."

Discuss with Students

When the body of a woman washes up on the shore in Los Angeles, Larry notices that a tattoo on her foot, consisting of lines and dashes, is actually a set of I Ching hexagrams (each made up of six lines, either solid or dashed). Charlie expends a great deal of mathematical energy on trying to interpret its meaning, but it is Amita who discovers the truth. Each hexagram is actually the symbol for a philosophical concept. A hexagram is made up of two *trigrams*, or series of three lines, stacked one on top of the other. A line is either *yin* (dashes, representing the "receptive principle") or *yang* (solid line, representing the "creative principle"). The lower trigram describes an inner (personal) aspect as related to the upper trigram, which is the outer (external) aspect or situation.

While each trigram and hexagram has meaning and many implications, these should be studied in greater detail in a more philosophical or cosmological setting. In this activity, students will learn the basic structure of trigrams and hexagrams, along with a little information on their meanings. The complete set of 64 hexagrams is also numbered from 01 to 64, and while the numbering system is not part of the activity, it is relevant to "Undercurrents."

Student Page Answers:

1. *Because each of the 3 lines of a trigram can be either dashed or solid, there are $2^3 = 8$ possibilities in all.*

2. *Order may vary. One way is to show all possibilities for one dashed line, then two dashed lines, as shown:*


3. *$8 \times 8 = 64$*

4. *Answers may vary. Using one hexagram, the first 26 could be used to encode the letters of the alphabet. These could even be combined with a shift cipher to encrypt a message. With two, any four-digit number, such as birthdates, could be encoded, provided that neither the first nor second pair of digits is higher than 64. Three hexagrams could represent five- or six-digit numbers (for a five digit number, use 01 – 09 for the first digit), such as a ZIP code or a student number. The same limitations apply, namely no consecutive pair of digits can exceed 64.*

5. *Any 9 or 10 digit number. Examples include a Social Security number, a ZIP code with the +4 digits, or a telephone number (including area code). The same limitations apply.*

Name: _____   Date: _____

NUMB3RS Activity: Numb3rs of the I Ching

When the body of a dead woman washes up on the Los Angeles shore, Larry notices that she has a tattoo on her foot in the form of five **I Ching** symbols, or hexagrams. Charlie expends a great deal of mathematical energy trying to determine their meaning, although Amita is the one who discovers the truth. The tattoo looks like this:
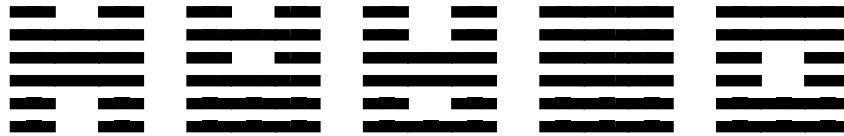
and translates as Influence, Waiting, Abundance, Strength, and Inner Truth.

Each symbol is called a hexagram because it is made up of six lines, either dashed (*yin*, or "receptive principle") or solid (*yang*, or "creative principle"). In turn, each hexagram is made up of two *trigrams*, or sets of three lines. The lower trigram describes an inner (personal) aspect as related to the upper trigram, which is the outer (external) aspect or situation.

1. Why are there exactly eight trigrams?

2. In the spaces below, use a pattern to generate all eight I Ching trigrams, using the first and last as a guide.

   _____ _____ _____ _____ _____ _____

3. Because each hexagram consists of a lower and upper trigram, how many possible I Ching hexagrams are there?

Charlie believes that the I Ching tattoo on the victim's foot may be some kind of encoded or encrypted message. In truth, each hexagram has its own number (see the Extensions page of this activity). For the victim's tattoo, they are: Influence (31), Waiting (05), Abundance (55), Strength (01), and Inner Truth (61).

Suppose you wanted to encode information using I Ching hexagrams. For example, if your birthday is October 3rd, you could encode this with two hexagrams; 10 and 03. Your code would look like this:
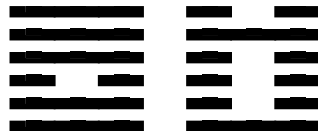
4. Because the hexagrams are numbered from 01 to 64, what kinds of data could you encode using one, two, or three hexagrams? What limitations are there?

5. The victim's tattoo consisted of five hexagrams. What kind of numerical information do you think this could represent? Again, what limitations are there?

The goal of this activity is to give your students a short and simple snapshot into a very extensive mathematical topic. TI and NCTM encourage you and your students to learn more about this topic using the extensions provided below and through your own independent research.

Extensions: Origins of the Binary System

Introduction

Gottfried Wilhelm Leibniz (1646 – 1716) wrote *On the Art of Combination* in 1666. In it, he argued for a language totally free of being spoken or written, namely mathematical and logical. The concept was ignored for about ten years, until he came upon a copy of the **I Ching**. He perceived a way to represent dashes (yin) by 0s and solid lines (yang) by 1s. Using the philosophy of such relationships as light/dark, male/female, heaven/earth, fire/water, and yes/no relationships from the **I Ching**, he reasoned that it should be possible to reduce life itself to a set of logical statements or principles. This led him to refine his rudimentary *binary system*, where numbers are represented as a series of 0s and 1s. Place value is represented as powers of two, as opposed to our decimal numbers, which use powers of ten. Ultimately, the binary system became the base for the digital computer, using "off" and "on" to represent 0s and 1s.

For the Student

For more about Leibniz' work on the binary system, see:
http://www.kerryr.net/pioneers/leibniz.htm

For more on how the binary system is the basis for digital computers, see:
http://www.kerryr.net/pioneers/binary.htm

Additional Resources

For a complete table of the I Ching hexagrams, their numbers, and their meanings, see:
http://members.ozemail.com.au/~ddiamond/table.html

For an adventure into the generation of I Ching meanings, connections, and even poetry, see the *I Ching Poetry Engine* at:
http://levitated.net/exhibit/iching/images.html