### SIENA COLLEGE

**22nd Annual**

### High School Programming Contest

##### April 3, 2009

###### **Problem #4: Gray Codes**

Background Information: Frank Gray was a physicist and researcher at Bell Labs who was awarded many patents for his work related to televisions in the 1930’s and 1940’s. He is also remembered as the inventor of the Gray code, or reflected binary code, which he patented in 1953 with relation to analog to digital conversion. The Gray code is a binary numeral system often used in electronics, but with many applications in mathematics.[[1]](#footnote-2)

A Gray code is a way of representing binary integers such that successive values differ from each other in only one bit position. To convert binary to Gray code, apply the exclusive or operator bit by bit to the binary value and a right-shifted version of itself, for example:

0111 binary 7

XOR 0011 right-shifted binary 7

0100 Gray 7

A right-shifted binary number is one where all the bits have been moved to the right one binary place, with a zero moving into the leftmost binary place and the original rightmost bit disappearing. Gray codes can be produced for N bits. The table below is a four-bit Gray code. Gray codes of 4 bits are more are not unique.

|  |  |  |
| --- | --- | --- |
| Decimal Integer | Binary Equivalent | Gray Code |
| 0 | 0000 | 0000 |
| 1 | 0001 | 0001 |
| 2 | 0010 | 0011 |
| 3 | 0011 | 0010 |
| 4 | 0100 | 0110 |
| 5 | 0101 | 0111 |
| 6 | 0110 | 0101 |
| 7 | 0111 | 0100 |
| 8 | 1000 | 1100 |
| 9 | 1001 | 1101 |
| 10 | 1010 | 1111 |
| 11 | 1011 | 1110 |
| 12 | 1100 | 1010 |
| 13 | 1101 | 1011 |
| 14 | 1110 | 1001 |
| 15 | 1111 | 1000 |

Programming Problem:

Input: The value of a positive N less than 10.

Output: An N-bit table similar to the one shown above. One line per table row must be printed. The

formatting of the output should have numbers separated only by a comma. No headers should be printed.

###### Example 1: Input: 1

###### Output: 0,0,0

###### 1,1,1

Example 2: Input: 3

Output: 0,000,000

1,001,001

2,010,011

3,011,010

4,100,110

5,101,111

6,110,101

7,111,100

1. See <http://www.answers.com/topic/gray-code> for more information after the contest. [↑](#footnote-ref-2)