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## Gray code

created by [lumina](#)

[\(thing\)](#) by [lumina](#) (?) [\(print\)](#)

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Sat Nov 13 1999 at 10:27:22

A code for numbers such that the representations of any two successive [numbers](#) differ by exactly one [digit](#). The most famous Gray codes are the [binary](#) Gray codes, which are used for various applications in [logic design](#) and [electrical engineering](#). Compare [Karnaugh map](#), [digital logic](#), [Hamiltonian path](#), [hypercube](#), [error-correcting codes](#), [ADC](#), [DAC](#).

[\(thing\)](#) by [m\\_turner](#) (1.6 y) [\(print\)](#)

[?](#) [\(I like it!\)](#) 1 C!

Sat Sep 16 2000 at 22:52:11

One example of a [binary grey code](#) follows. Please note the [number](#) of [bits](#) that change for each number and the reflections that exist in the counting system.

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

The primary use for this is the elimination of [race conditions](#) caused by changing two [bits](#) at the same time.

[\(idea\)](#) by [Baron Saturday](#) (6.9 y) [\(print\)](#)

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Tue Jan 09 2001 at 0:08:06

One useful [non-technical](#) application of gray code is [computer games](#) which include [puzzles](#) that involve having a series of switches in the correct positions. Using gray code, it is possible to test all possible positions for the switches with a minimal amount of effort.

[\(idea\)](#) by [hobyme](#) (3 y) [\(print\)](#)

[?](#) [\(I like it!\)](#) 2 C!s

Mon Jun 04 2001 at 23:31:57

[Encoding](#) a [binary value](#) to a [Gray code](#) value is accomplished by the following [C function](#):

```
unsigned long binary_to_gray(unsigned long n)
```

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```
{
  return (n ^ (n >> 1));
}
```

Decoding is slightly more [tricky](#), the following function will do it:

```
unsigned long gray_to_binary(unsigned long n)
{
  unsigned long sh;
  unsigned long nn;
  sh = 1;
  nn = (n >> sh);
  while (nn > 0) {
    n ^= nn;
    sh <<= 1;
    nn = (n >> sh);
  }
  return (n);
}
```

It is very [interesting](#) to note that `binary_to_gray` is the same [transformation](#) as changing a binary [string](#) from [fully coherent](#) to [differentially coherent](#) (change on 1), and `gray_to_binary` is the same transformation as changing from differentially-coherent (change on 1) to fully-coherent.

So, to change from binary to Gray: write out the binary string one line of a page. Copy the [leftmost bit](#) to the line below (assuming the most [significant](#) bit is on the left, which it [usually](#) is). Repeat for all following bits on the top line: if it's the same as the [previous](#) bit, add a '0' to the Gray code; otherwise, add a '1' to the Gray code. (A proof by [induction](#) can show that two [successive](#) numbers encoded in this manner will have precisely one bit changed after the Gray code transformation.)

To change from Gray to binary: write out the Gray string. Copy the leftmost bit to the line below. Repeat for all following bits: if it's a '0', copy the previous bit of the binary string; if it's a '1', write the inverse of the previous bit.

The grey code can be [padded](#) on the left with 0s just like binary values, or 0s on the left can be ignored just like with binary.

Another interesting property of Gray codes is that  $(\text{binary\_to\_gray}(x \oplus y) == (\text{binary\_to\_gray}(x) \oplus \text{binary\_to\_gray}(y)))$  and  $(\text{gray\_to\_binary}(x \oplus y) == (\text{gray\_to\_binary}(x) \oplus \text{gray\_to\_binary}(y)))$ .

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