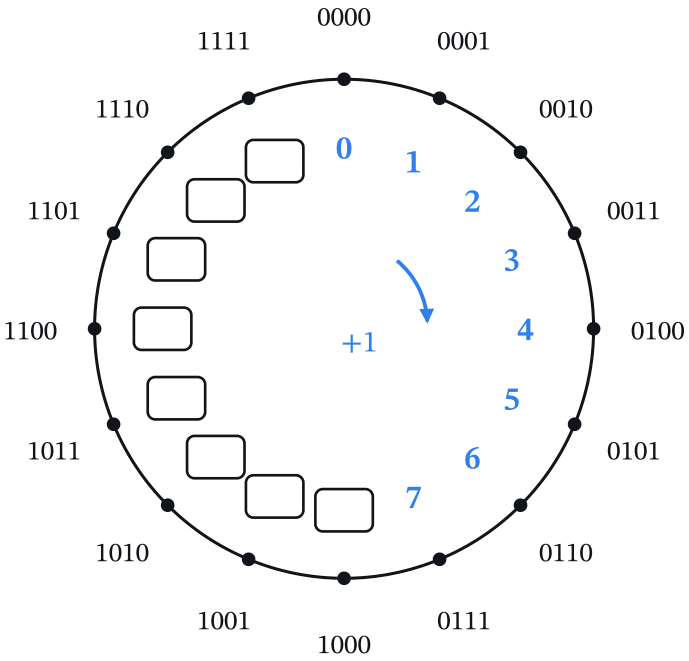
Names (pair) _____ Date _____

# Two's Complement

**Remember**

With 4 bits we have 16 codes. How can we write negative numbers? If we count **backwards** from 0000, the next code is 1111, so $1111 = -1$. In **two's complement**, codes that start with 1 are negative, and the first bit is the **sign bit**.




**1** IN PAIRS **The number circle.** Each step in the direction of the arrow adds 1. Start at 0, go backwards and write $-1, -2, \ldots, -8$ in the empty boxes.

**2** IN PAIRS What happens if we take one more step forward from $0111 = 7$?

**3** IN PAIRS Read these from the circle.

$-1 =$ ☐ $-3 =$ ☐

$-6 =$ ☐ $-8 =$ ☐

Name _____ Date _____

The rule for $-x$

Write $x$ in binary, **flip** all the bits ($0 \leftrightarrow 1$) and **add** $1$.

$3 = 0011 \rightarrow 1100 \rightarrow 1100 + 1 = 1101 = -3$

**4** ON YOUR OWN Use the rule (4 bits) and check on the circle.

| $x$ | Binary | Flipped bits | $+1 \rightarrow -x$ |
|---|---|---|---|
| 1 | | | |
| 3 | | | |
| 6 | | | |

**5** ON YOUR OWN Which number does each code stand for (4 bits, two's complement)?

$1110 =$ ☐ $1001 =$ ☐

$0111 =$ ☐ $1000 =$ ☐

**6** ON YOUR OWN Write in two's complement with $8$ bits.

$-1 =$ ☐ $-100 =$ ☐

**7** IN PAIRS **Range.** What are the smallest and largest numbers?

| Bits | Smallest | Largest |
|---|---|---|
| 4 | | |
| 8 | | |
| $n$ | | |

**The Two's Complement app · otooly.com/twos-complement**

**Table** mode: compare codes and numbers; **Convert** mode shows flipping the bits and adding $1$.

★ ON YOUR OWN **Exit card.** Write $-7$ with 4 bits. ☐