Which of the transistors below are on?

Submit your answer on menti.com with code 24 34 75
Two levels of thinking about transistors

**Voltage/circuit level**

Transistor only "knows" voltages across its pins.
An **NMOS** turns on when $V_{GS} > V_{th}$
A **PMOS** turns on when $V_{GS} < -V_{th}$

**Logic-level**

Assume: NMOS source $\rightarrow$ Vdd, PMOS source $\rightarrow$ Gnd
Assume: Inputs are HIGH (1, Vdd) or LOW (0, Gnd)
Then:
An **NMOS** turns on when input is high
A **PMOS** turns on when input is low
Time taken on homework:
By the end of today, you should be able to:

Represent numbers using binary, with 2's complement for negative values

Explain the various datatypes in Arduino, and predict overflow/underflow

Take a keyboard apart (and figure out how it works).
Binary numbers
Convert the following decimal numbers to binary:

4, 19, 63, 256

Convert the following binary numbers to decimal:

10001, 10101, 00111, 11111111
overflow!

binary integer
To write a negative number in 2's complement:

Write the **positive number** in binary

Flip all the bits \((1 \rightarrow 0, 0 \rightarrow 1)\)

Add 1 (with all the appropriate carries)

To convert negative 2's complement to decimal,

Flip all the bits \((1 \rightarrow 0, 0 \rightarrow 1)\)

Add 1 (with all the appropriate carries)

Write the number in decimal
unsigned overflow

binary

unsigned

signed

signed overflow
Convert the following decimal numbers to binary, using 8-bit 2's complement:

-1, -12, -128, 4

Convert the following 8-bit 2's complement binary numbers to decimal:

1000.0011, 0000.1011, 1111.1100
If you have 8 bits:

What is the largest signed number you can represent?

Smallest (most negative) signed number?
Casting from one data type to another \textit{doesn't} change the bits.

\begin{verbatim}
  unsigned char x = 253;
  char y = x;
  print(y);
\end{verbatim}

When you add more bits, the number \textit{shouldn't} change...

\begin{verbatim}
  char x = -1;
  int y = x;
  print(y);
\end{verbatim}
Building an adder
1...2...

BAAA

1,306...1,307...

BAAA

32,767...-32,768...

BAAA BAAA BAAA BAAA

-32,767...-32,766...

BAAA
Breaking break: Keyboards!