02 – TRANSISTORS TO GATES

COMP256 – COMPUTING ABSTRACTIONS

DICKINSON COLLEGE

COMP256 – COMPUTING ABSTRACTIONS

- Prof. Grant Braught
  - http://users.dickinson.edu/~braught/
    - Office hours, Meetings, Course Link
- Syllabus or Course Questions?

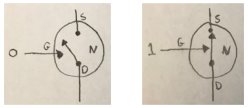
TRANSISTORS AS SWITCHES

- *Transistors* are electronic components that can behave as *electrically controlled switches.*
- Transistors are *solid-state* (i.e. no moving parts) devices.
- There are two basic types types of transistors, *N-Type* and *P-Type*.
  - Different switching behavior is produced by impurities added to the *silicon dioxide semi-conductor* during manufacturing in a process called *doping*.

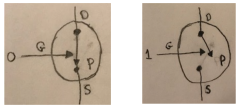
N-TYPE & P-TYPE SWITCHING TRANSISTORS

- Transistors have 3 connections: source (S), gate (G) and drain(D).
- The connection between the source (S) and the drain (D) "switches" open and closed based on the logic level (i.e. voltages) applied at the gate (G).

In an **N-Type** transistor the switch is open when a 0 is applied at the gate and is closed when a 1 is applied to the gate.

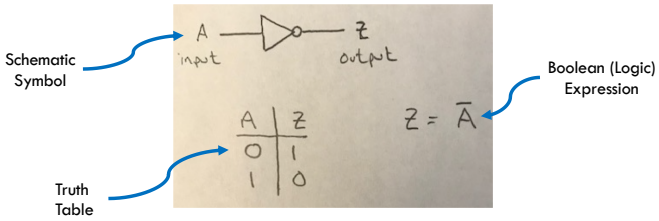


In a **P-Type** transistor the switch is closed when a 0 is applied at the gate and is open when a 1 is applied to the gate.



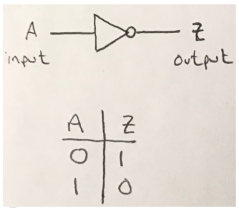
A NOT GATE ABSTRACTION

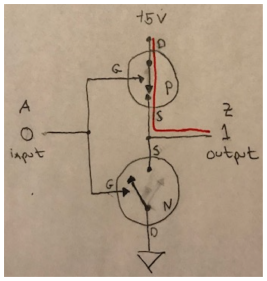
- A NOT gate is a circuit that takes a logical value (0 = false or 1 = true) as its input and *computes* its complement as its output.

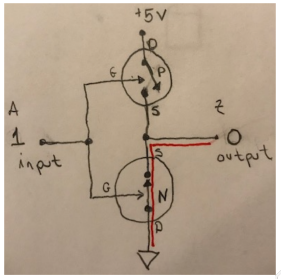


INSIDE THE NOT GATE ABSTRACTION

- A NOT gate is built using two transistors one P-Type and one N-Type.



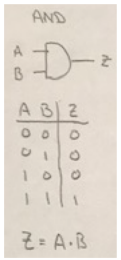


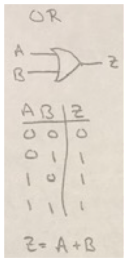


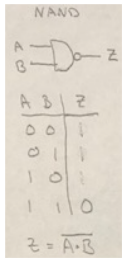
Note: The N-Type and P-Type transistors work in a complementary way. When one is open, the other is closed. This is the origins of the term *CMOS Technology* (Complementary Metal Oxide Semiconductor).

2-INPUT LOGIC GATES AS ABSTRACTIONS

- The common 2-input logic gates are:
  - **AND**
  - **OR**
  - **NAND**
  - NOR
  - XOR
  - XNOR



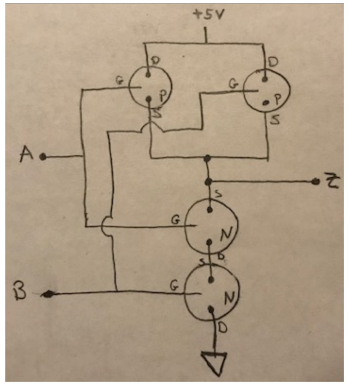




ACTIVITY

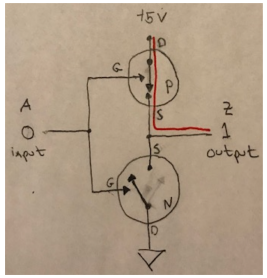
- What 2-input logic function is implemented by this circuit?

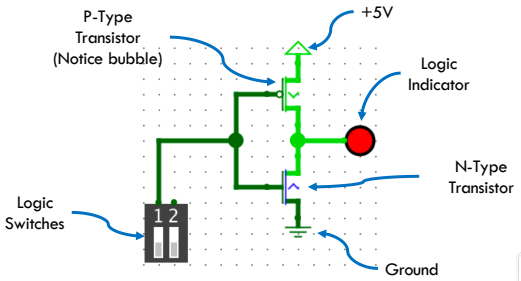
Note: For technical reasons P-Type transistors should always be on the +5V side of the circuit (top) and N-Type should always be on the ground side (bottom).



LOGISIM-EVOLUTION

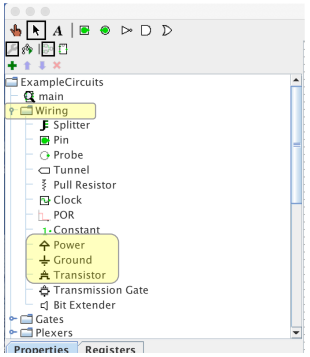
- Logisim-Evolution is a program that is able to simulate electronic circuits.
  - Download link and instruction are on the course home page.

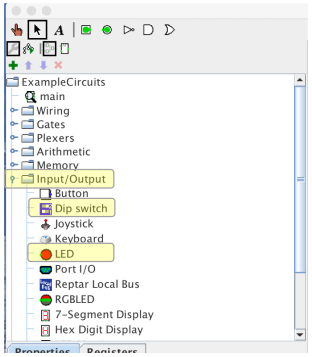




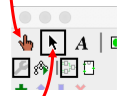
Note: For our circuits, arrows on the transistors in Logisim-Evolution will always point toward the output (i.e. the center of the circuit.)

LOGISIM-EVOLUTION: FINDING PARTS





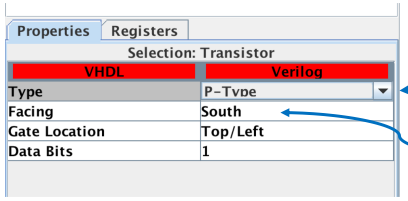
Run & interact with simulation tool



Build and wire circuits tool.

LOGISIM-EVOLUTION: COMPONENT PROPERTIES

- Click a component to bring up its properties in the lower left panel.
  - Example below is from a transistor.
  - Others are similar.
  - Play around, experiment, explore a bit.



Choose N-Type or P-Type From Dropdown

Most components can face N, S, E, W. Change orientation to make wiring cleaner.

ACTIVITY

- Use Logisim-Evolution to build and simulate a NOT gate using transistors.