

# Lab 7: Transistors

Largely replaced the vacuum tube

Heart of modern electronics

Three-terminal semiconductor device

Amplification and switching

Two basic forms (BJT and FET)

John Bardeen

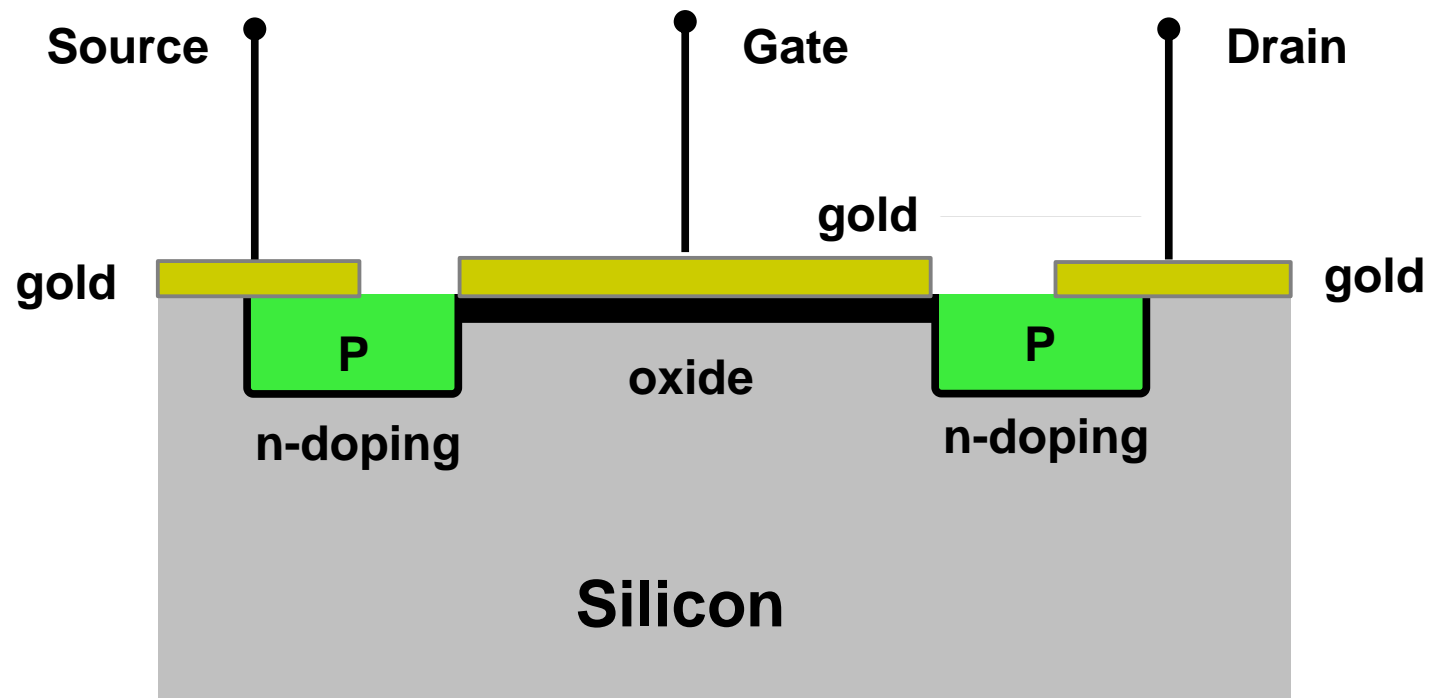
William Shockley

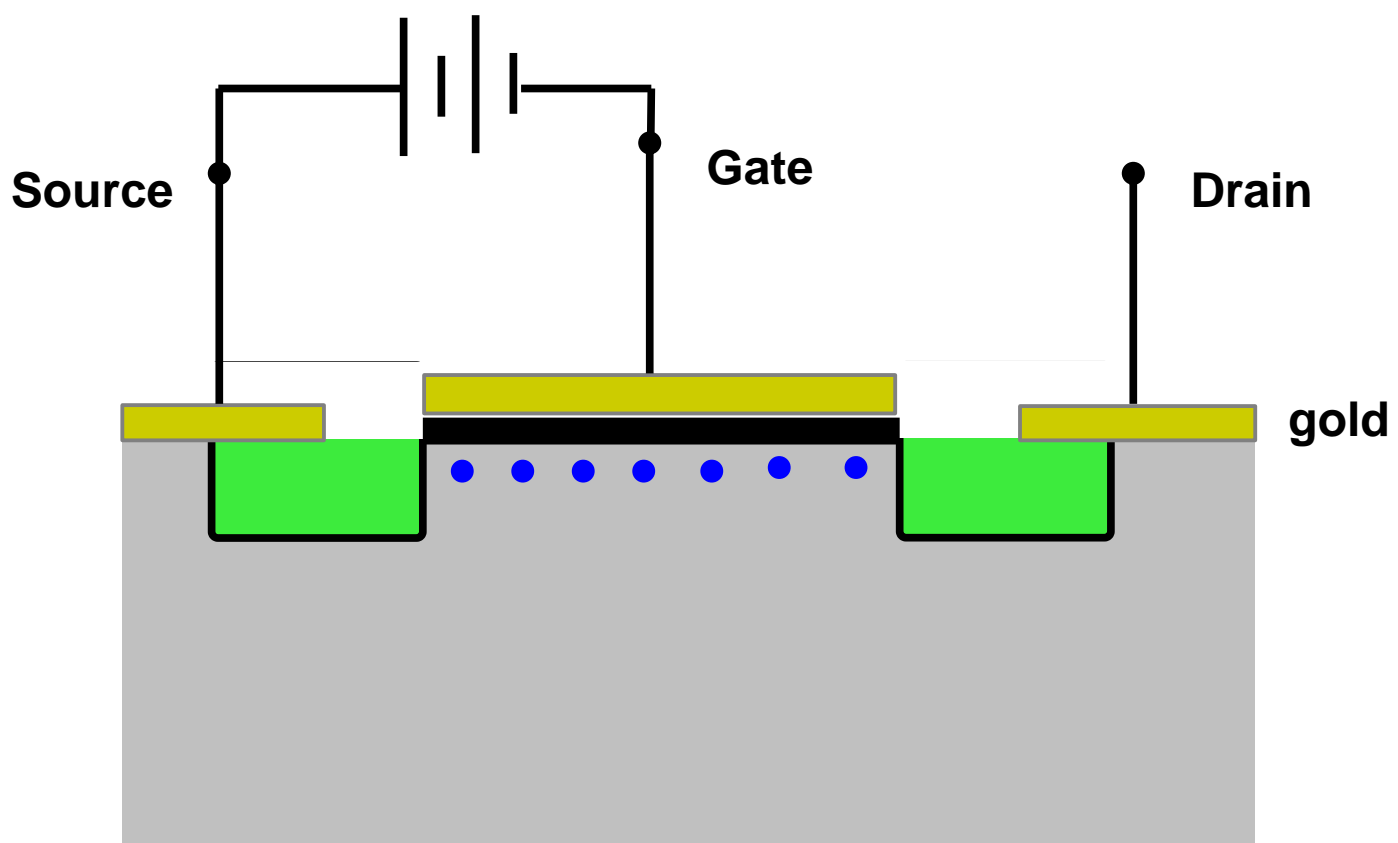
Walter Brattain

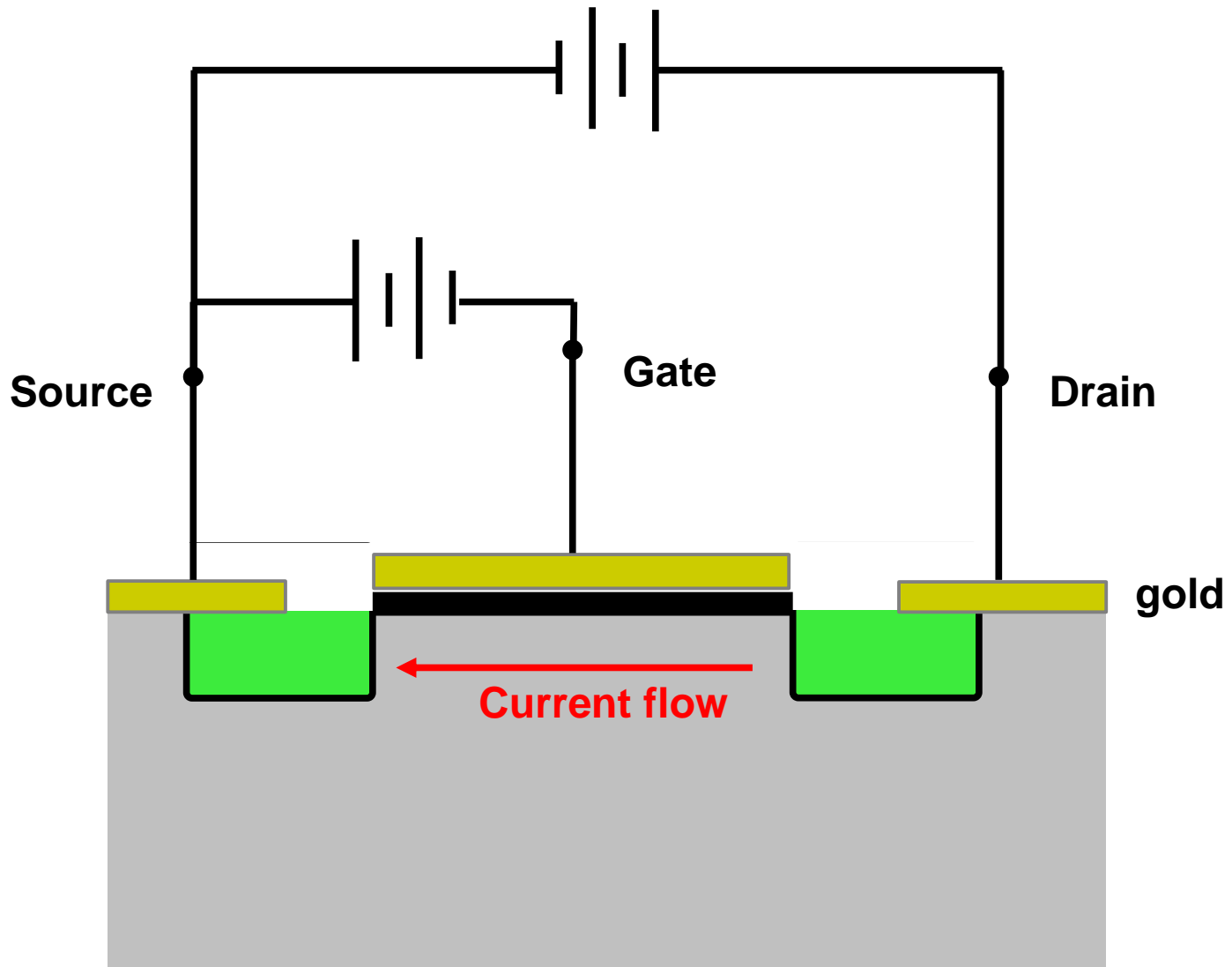


**1956 Nobel Prize in Physics**

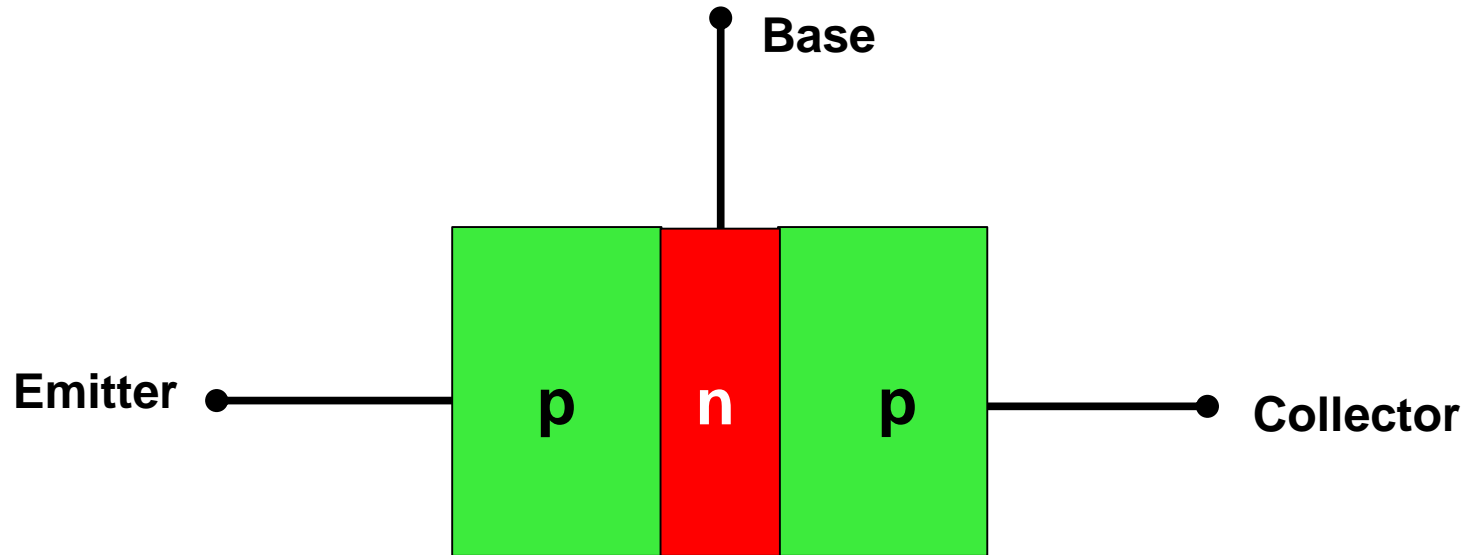
# MOSFET: Metal-Oxide-Semiconductor Field-Effect Transistor



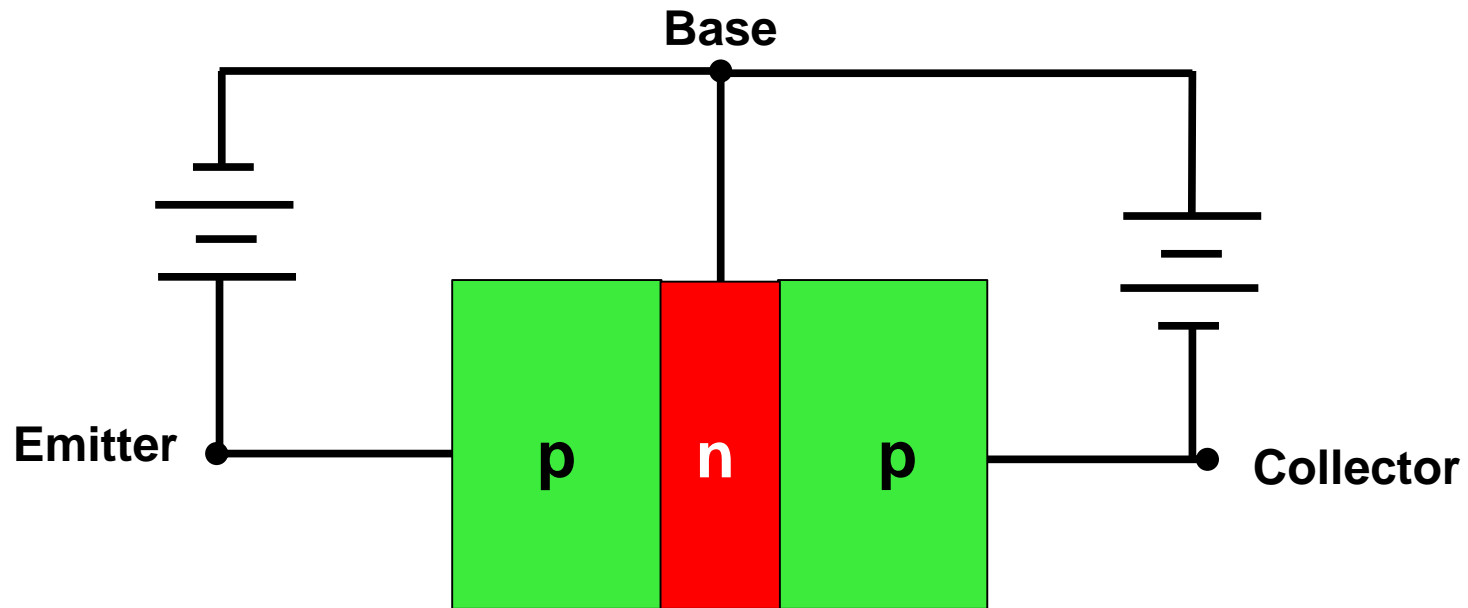




# BJT: Bipolar Junction Transistor

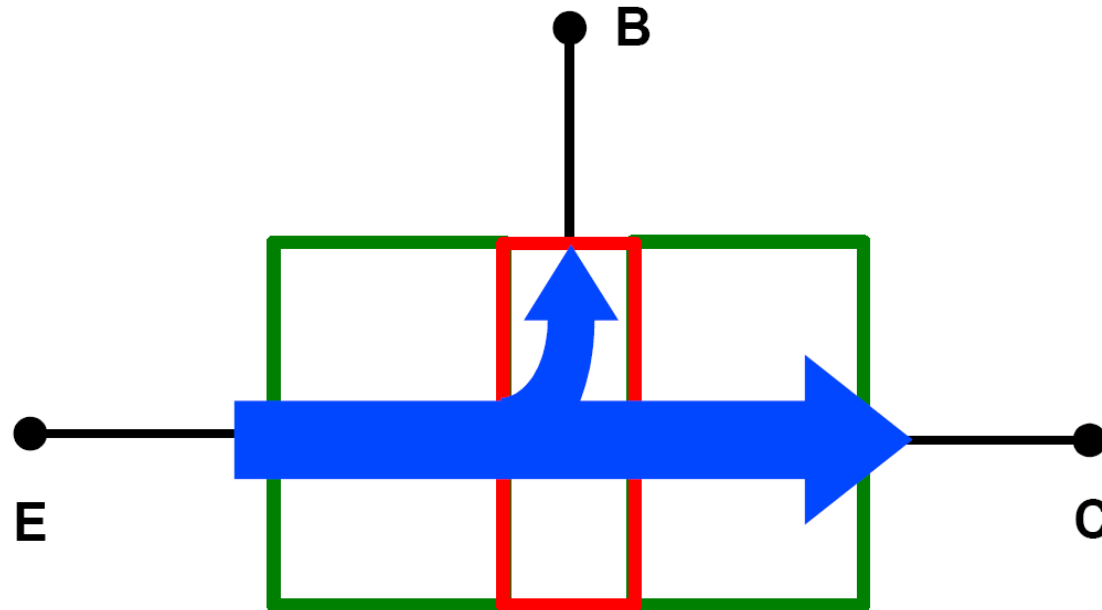


# BJT: Bipolar Junction Transistor

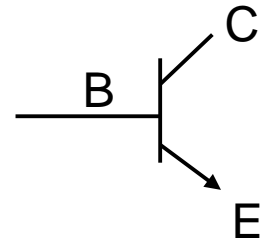
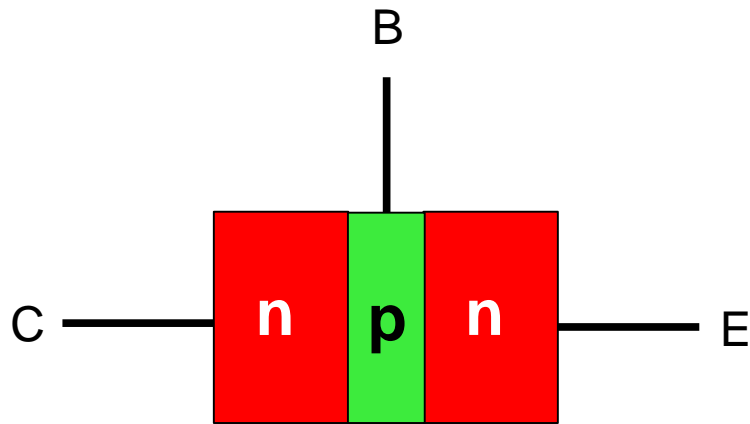
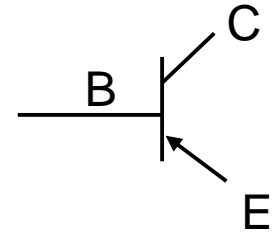
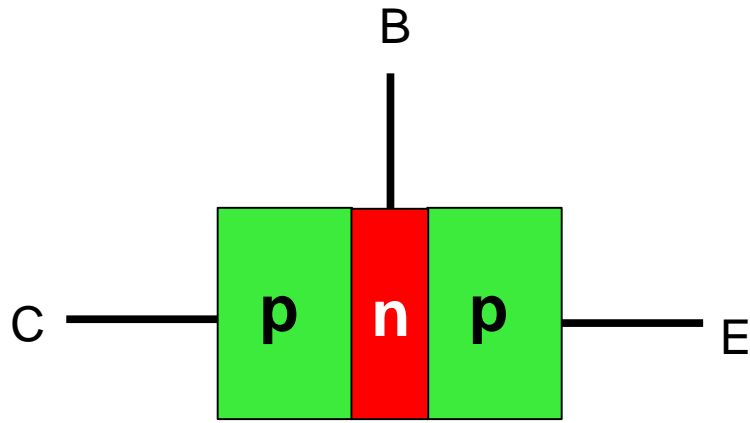




# BJT: Bipolar Junction Transistor

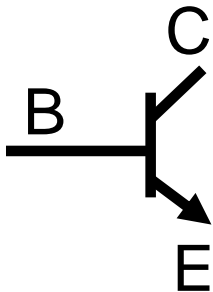
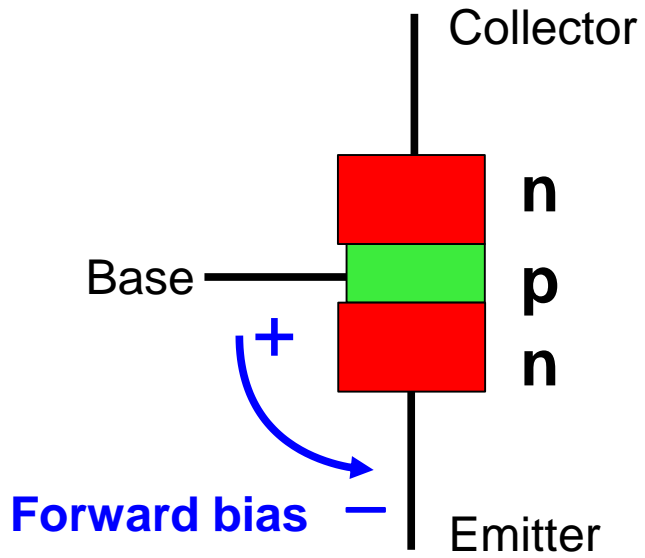


**Small base current controls  
Much larger collector current**



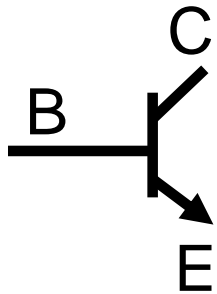
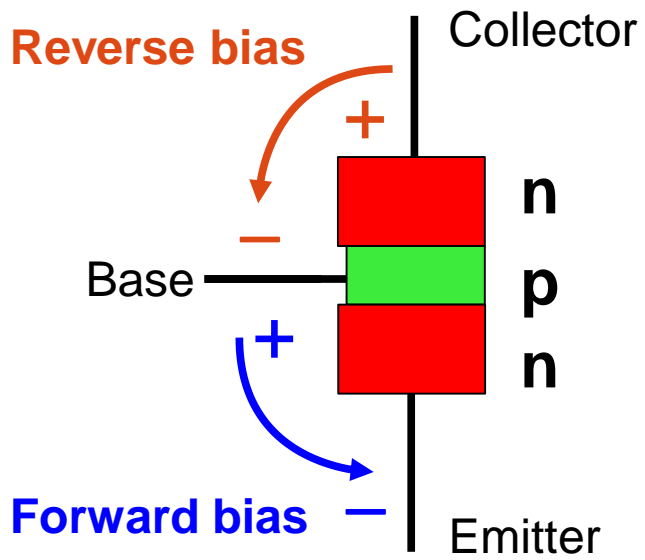
# Getting the dc voltages correct: **BIAS**

n-p-n transistor



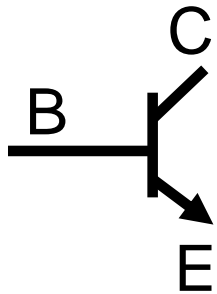
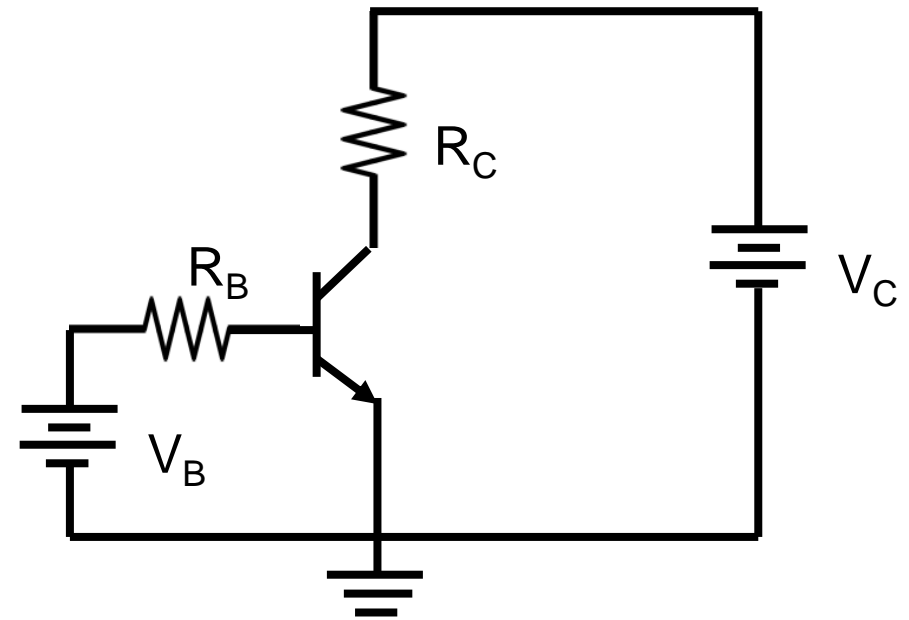
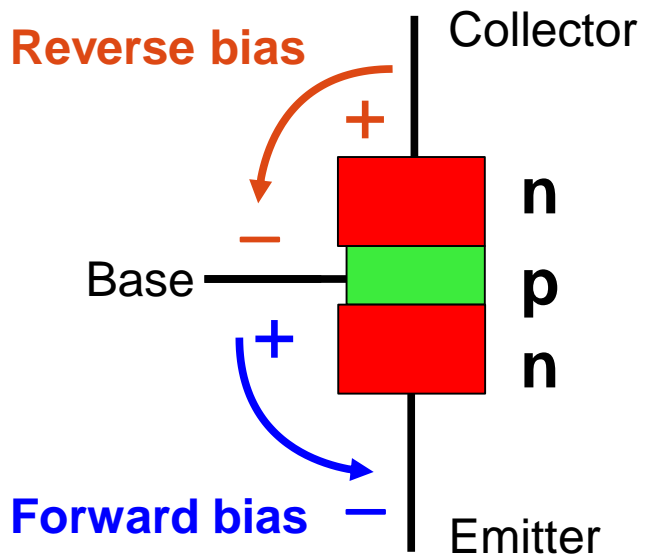
# Getting the dc voltages correct: **BIAS**

n-p-n transistor

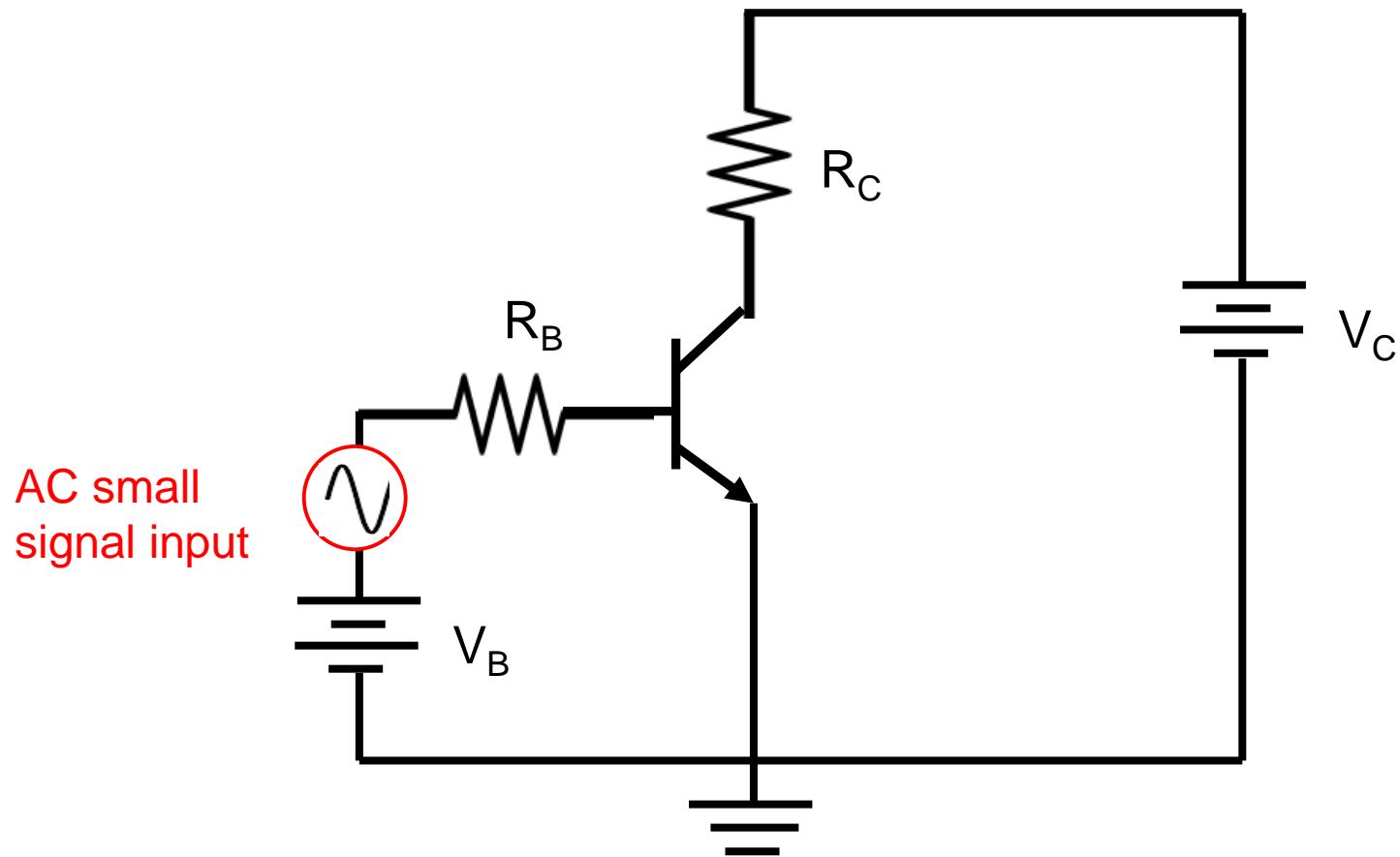


# Getting the dc voltages correct: **BIAS**

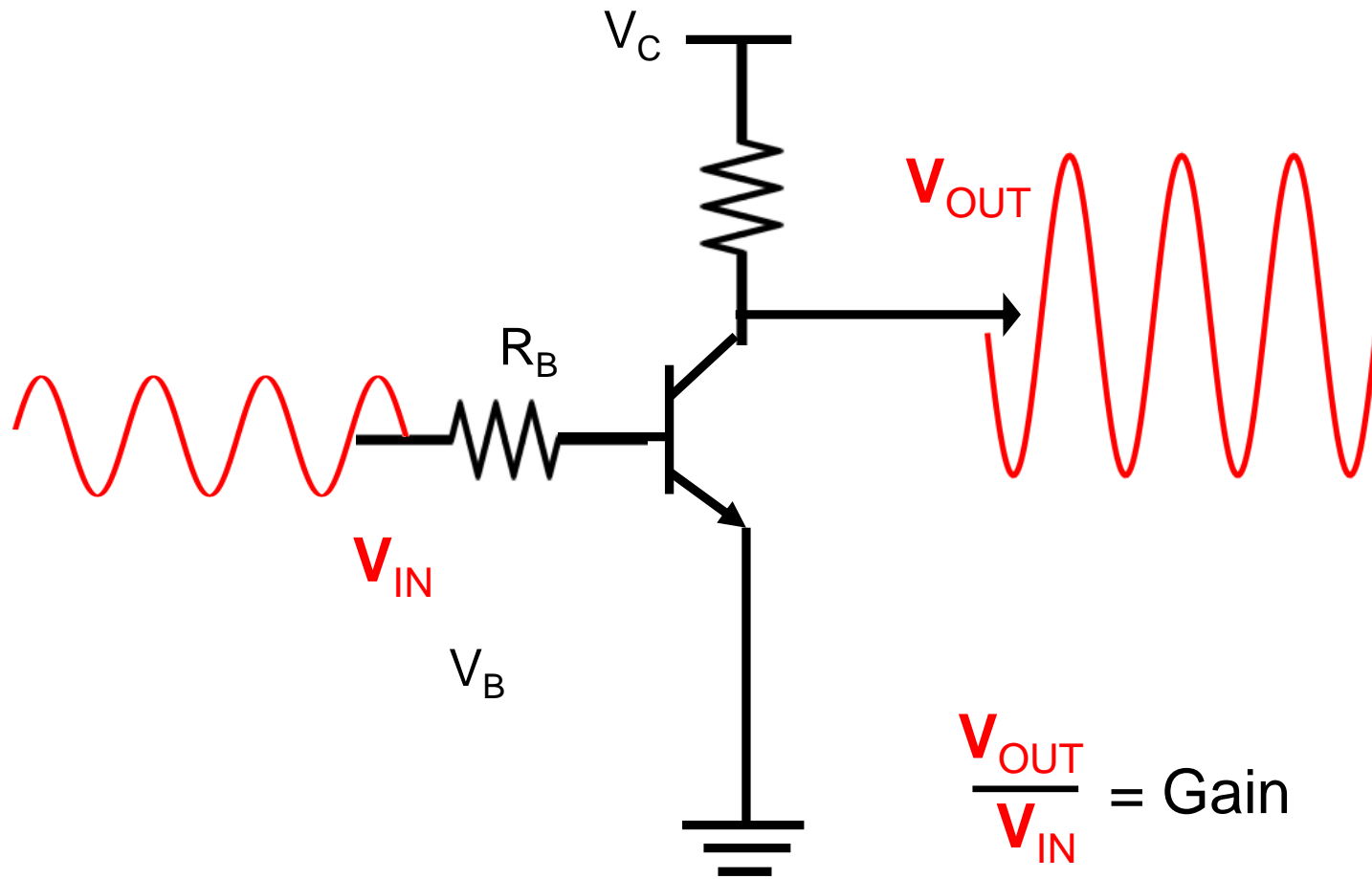
n-p-n transistor



# The BJT Amplifier

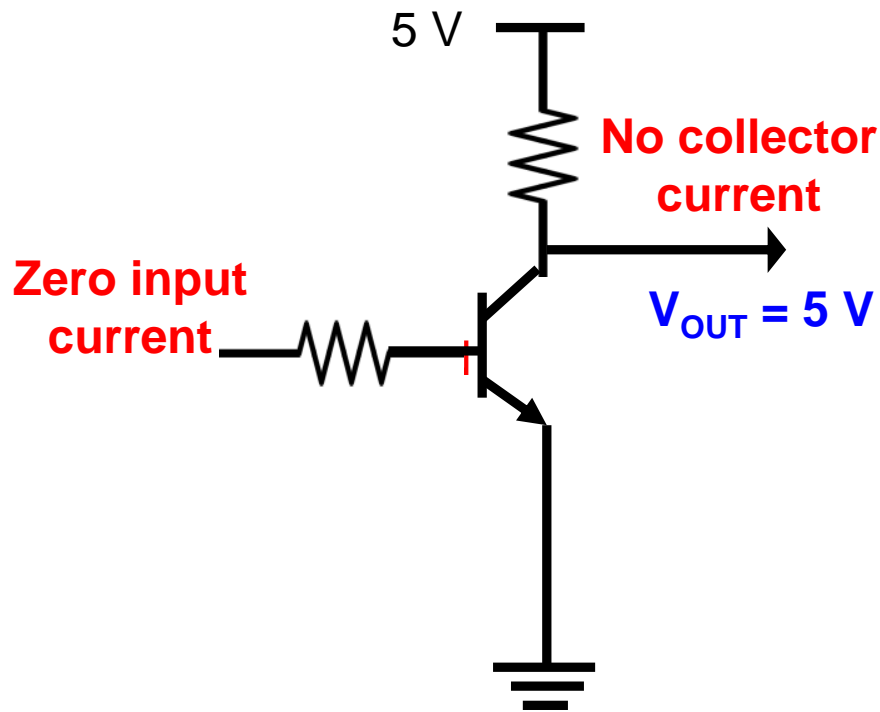


# The BJT Amplifier

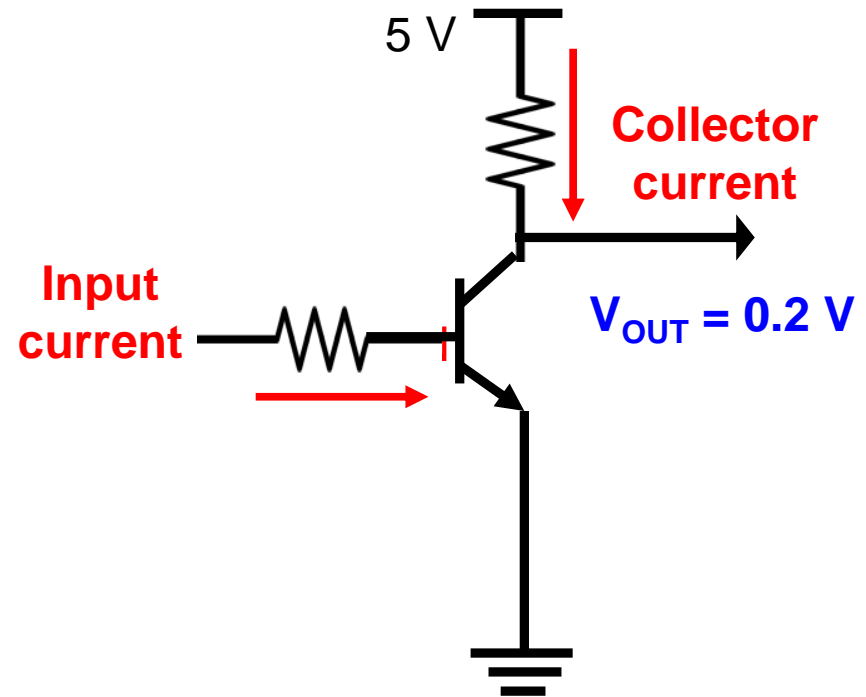


# The Transistor as a Switch

- No base bias voltage
- Input current turns transistor on and off



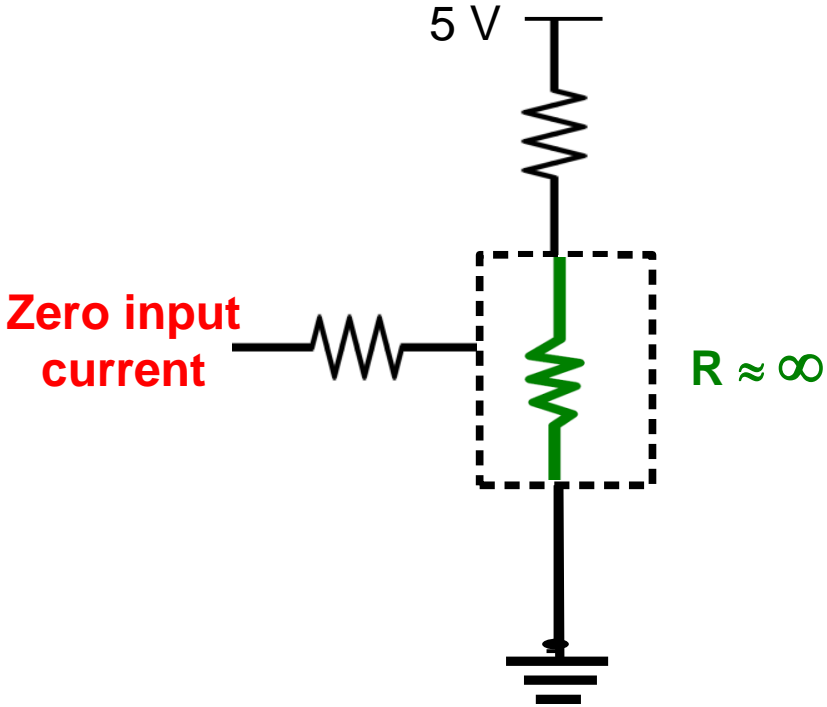
Transistor **OFF**



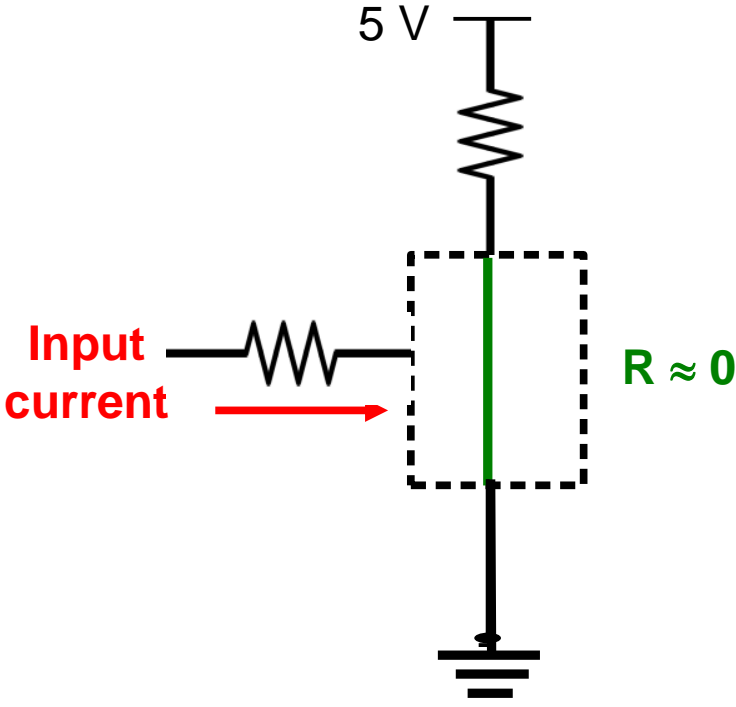
Transistor **ON**



# Intuitive picture of the transistor switch: Current-controlled resistor

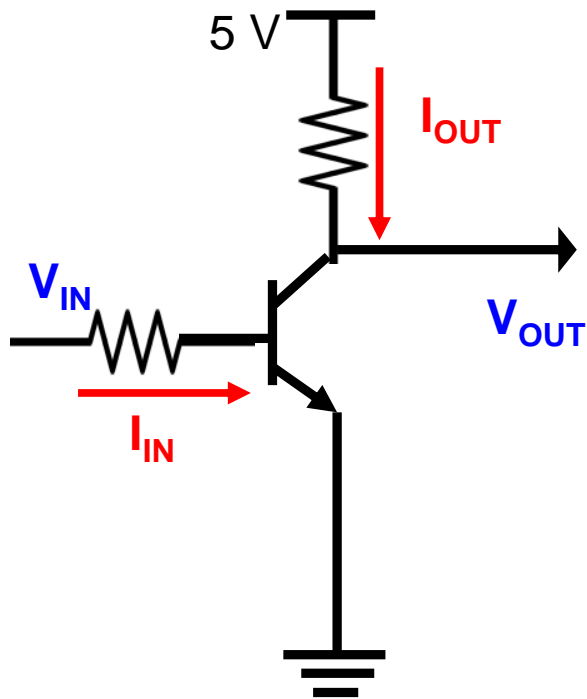


Transistor **OFF**



Transistor **ON**

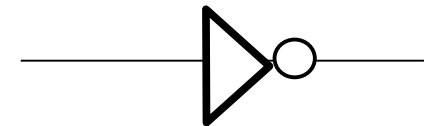
# The Transistor Switch: Boolean Logic Device



**LOGIC 0:** VOLTAGE  $< 0.4\text{ V}$   
**LOGIC 1:** VOLTAGE  $> 3\text{ V}$

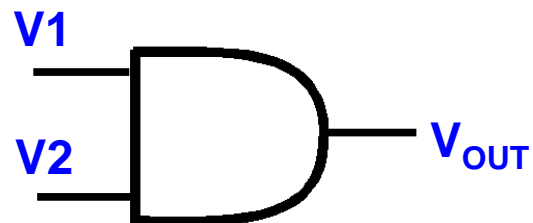
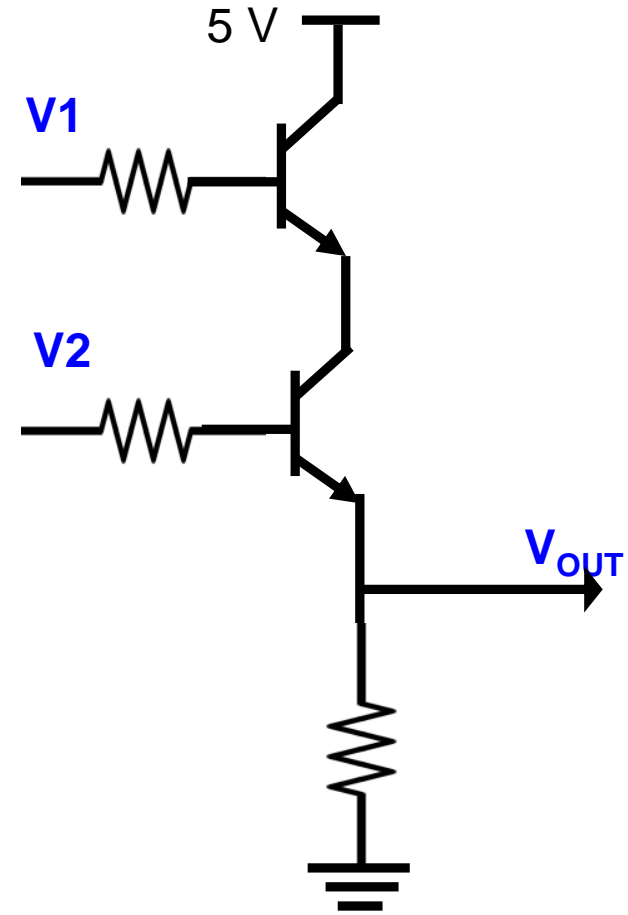
$V_{IN}$	$I_{IN}$	$I_{OUT}$	$V_{OUT}$
Logic 0	0	0	Logic 1
Logic 1	$\mu\text{A}$	$\text{mA}$	Logic 0

**NOT** Gate



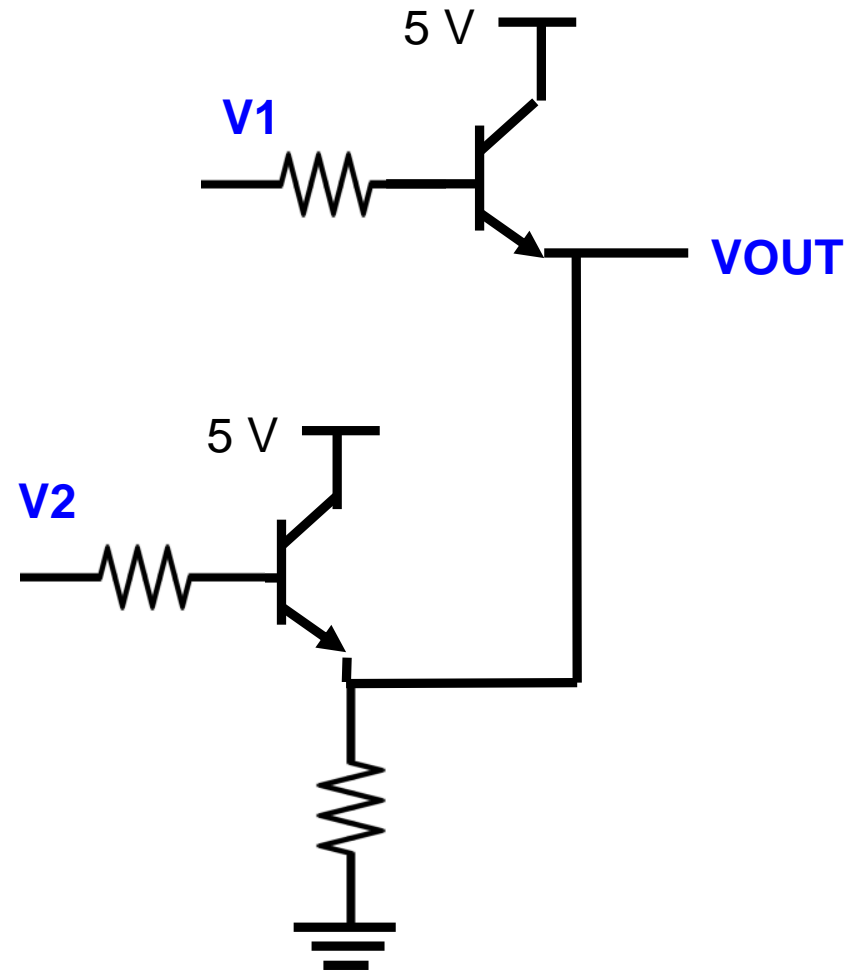
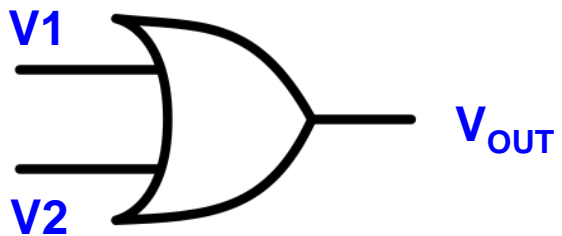
# The Transistor **AND** Gate

V1	V2	V <sub>OUT</sub>
0	0	0
1	0	0
0	1	0
1	1	1

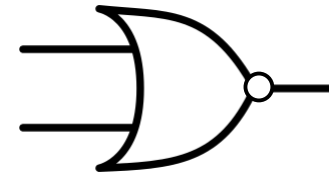


# The Transistor OR Gate

V1	V2	V <sub>OUT</sub>
0	0	0
1	0	1
0	1	1
1	1	1

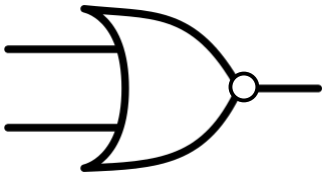


# The NOR Gate

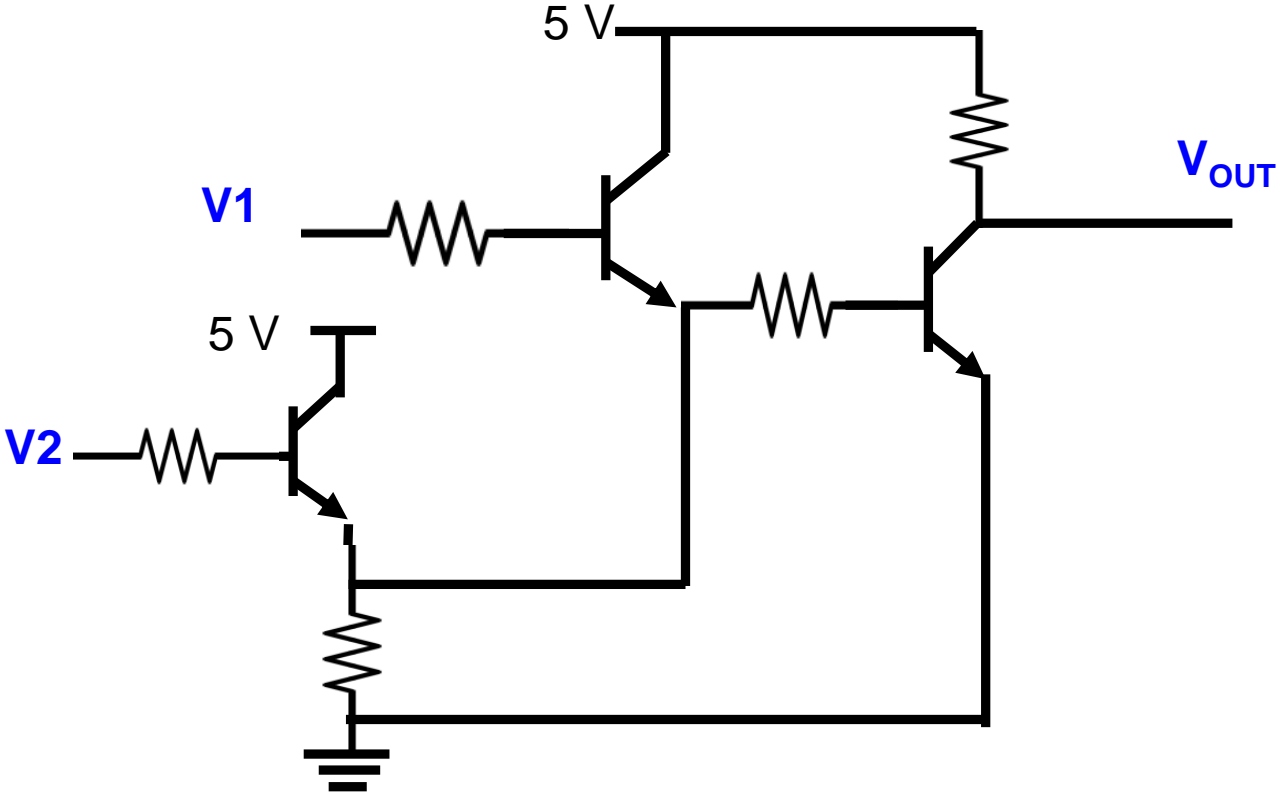
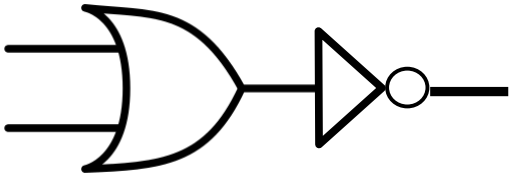


V1	V2	V <sub>OUT</sub>
0	0	1
1	0	0
0	1	0
1	1	0

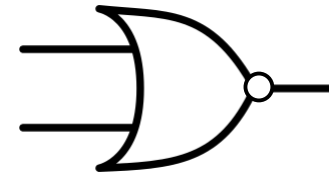
# The NOR Gate



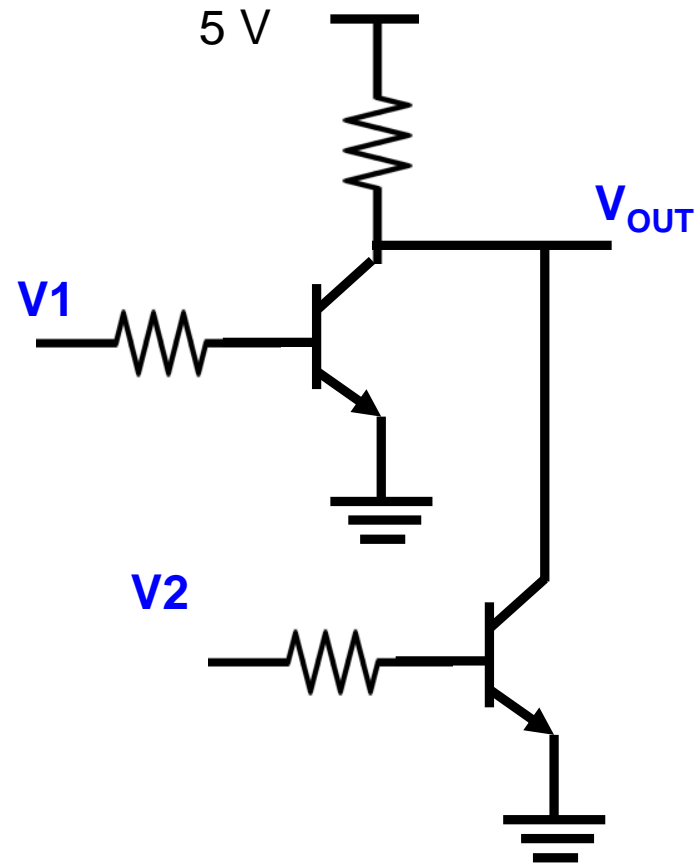
V1	V2	V <sub>OUT</sub>
0	0	1
1	0	0
0	1	0
1	1	0



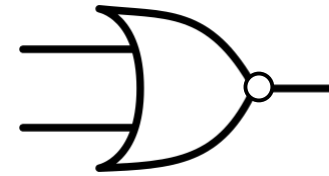
# The NOR Gate



V1	V2	V <sub>OUT</sub>
0	0	1
1	0	0
0	1	0
1	1	0



# The NOR Gate



V1	V2	V <sub>OUT</sub>
0	0	1
1	0	0
0	1	0
1	1	0

