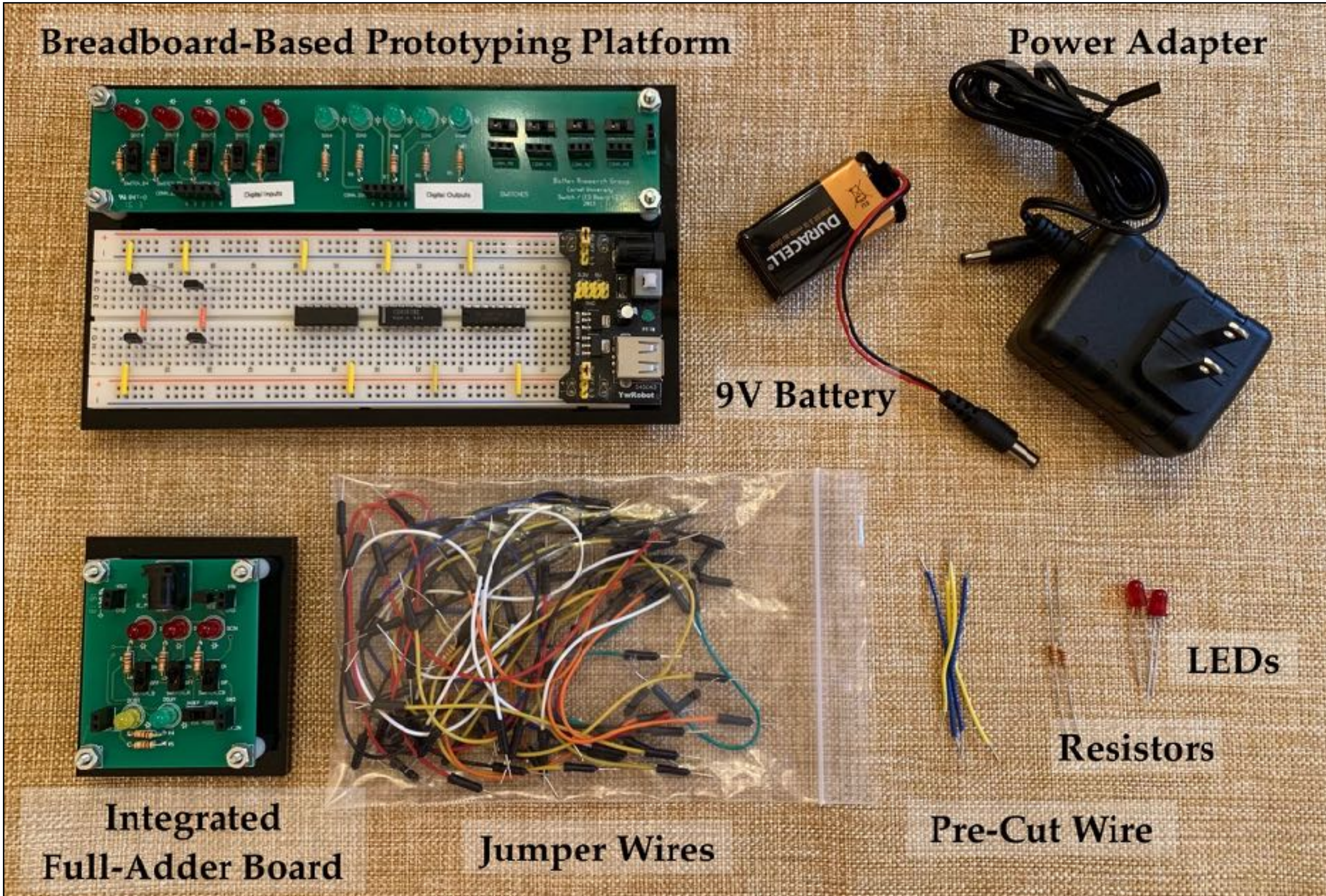
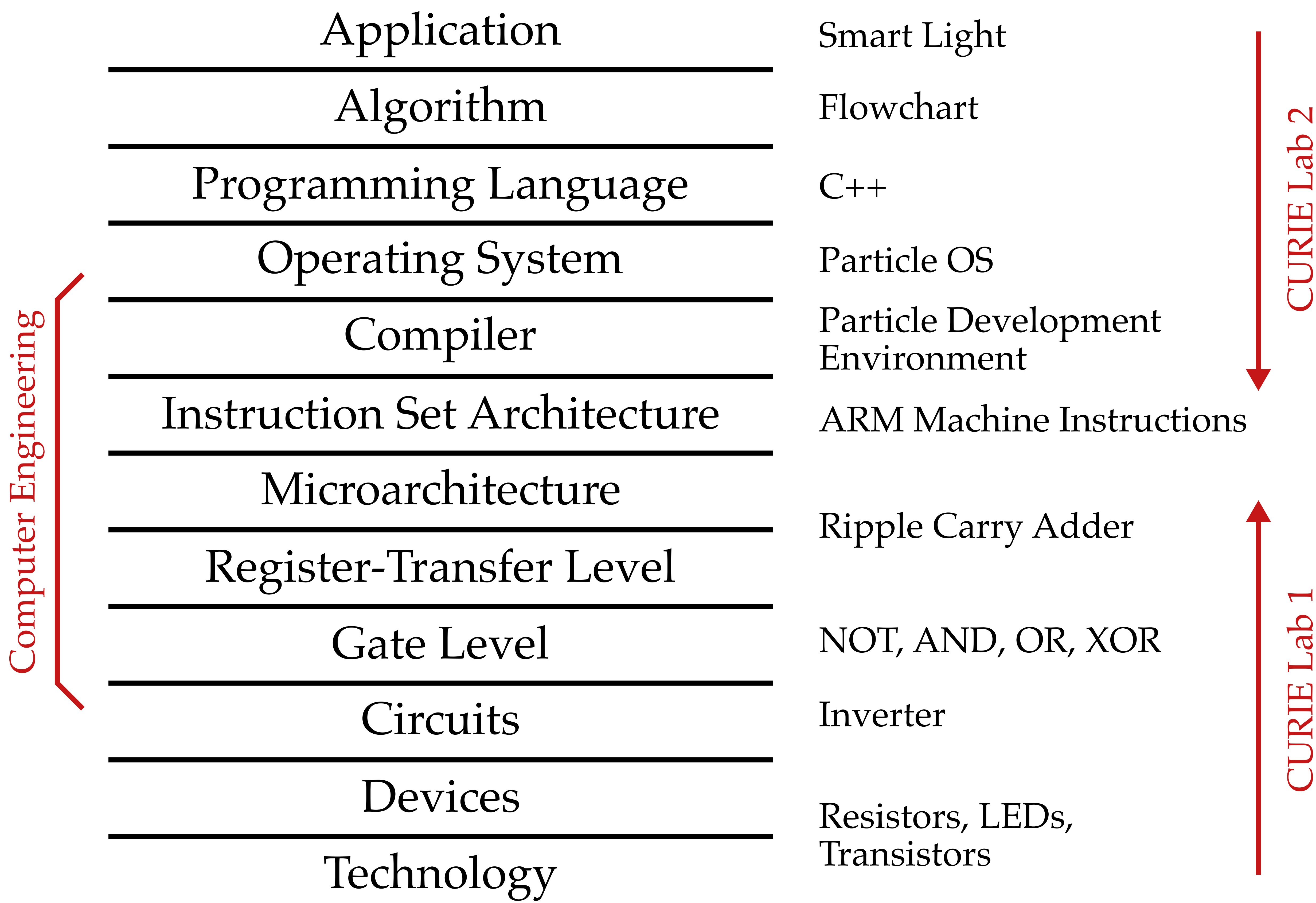
CURIE Academy, Summer 2021
Lab 1: Computer Engineering Hardware Perspective

Prof. Christopher Batten
School of Electrical and Computer Engineering
Cornell University

Materials Required for Lab 1



Computer Systems Stack



Computer Systems Stack

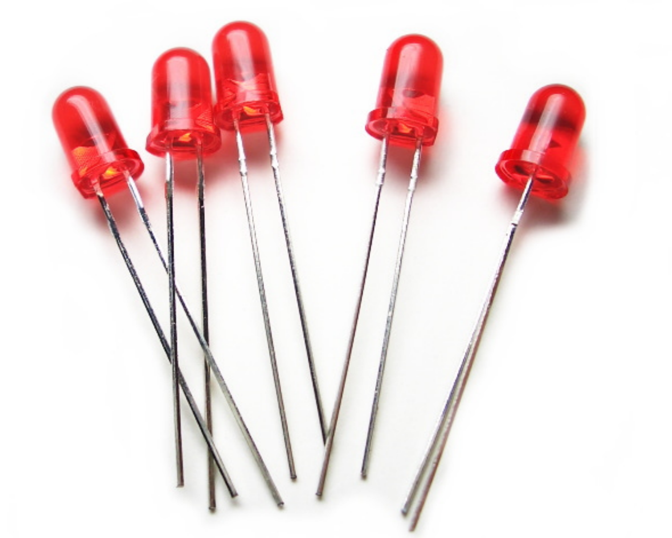
Application	Smart Light
Algorithm	Flowchart
Programming Language	C++
Operating System	Particle OS
Compiler	Particle Development Environment
Instruction Set Architecture	ARM Machine Instructions
Microarchitecture	Ripple Carry Adder
Register-Transfer Level	
Gate Level	NOT, AND, OR, XOR
Circuits	Inverter
Devices	Resistors, LEDs, Transistors
Technology	

Computer Engineering

CURIE Lab 2

CURIE Lab 1

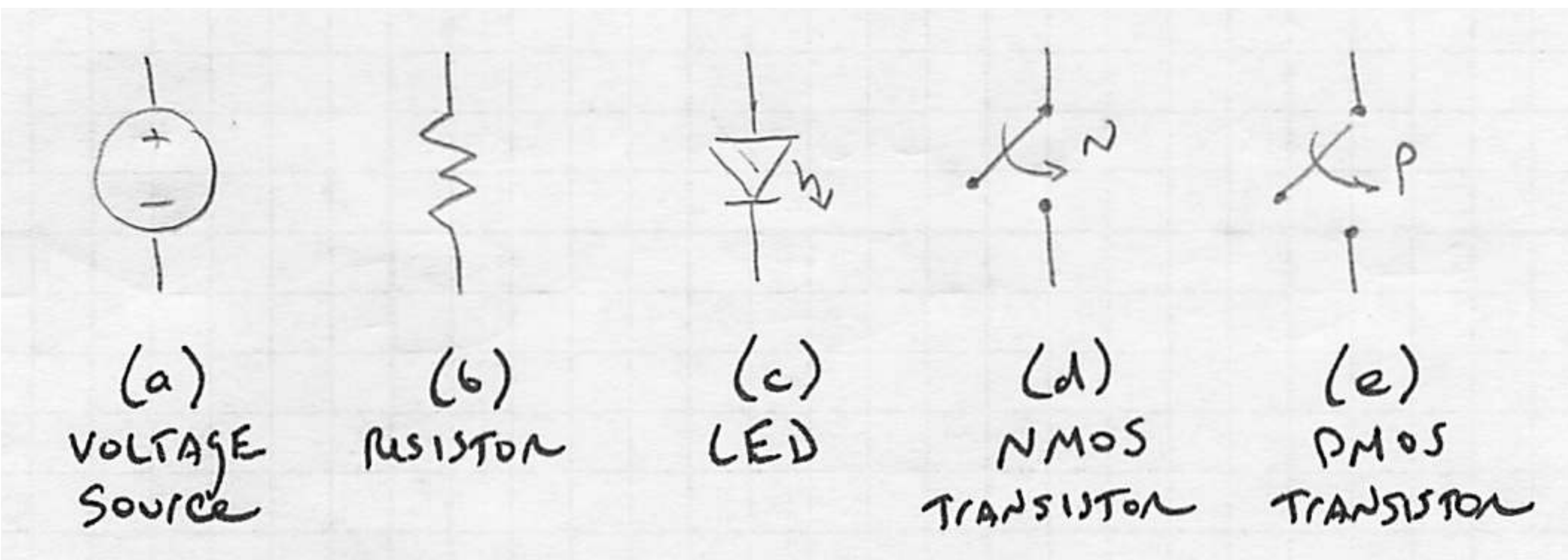
Various Electrical Devices



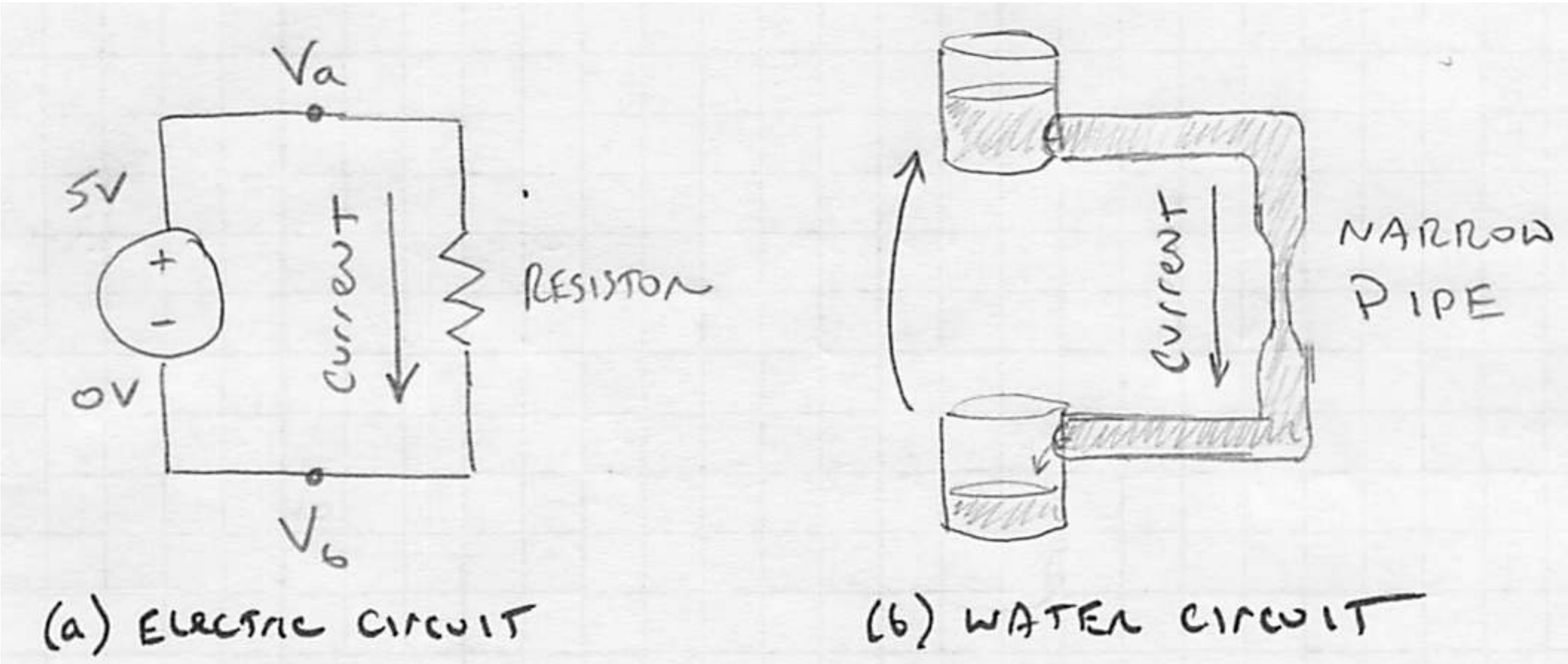
(a) LEDs

(b) Resistors

(c) Transistor



Basic Electrical and Water Circuit



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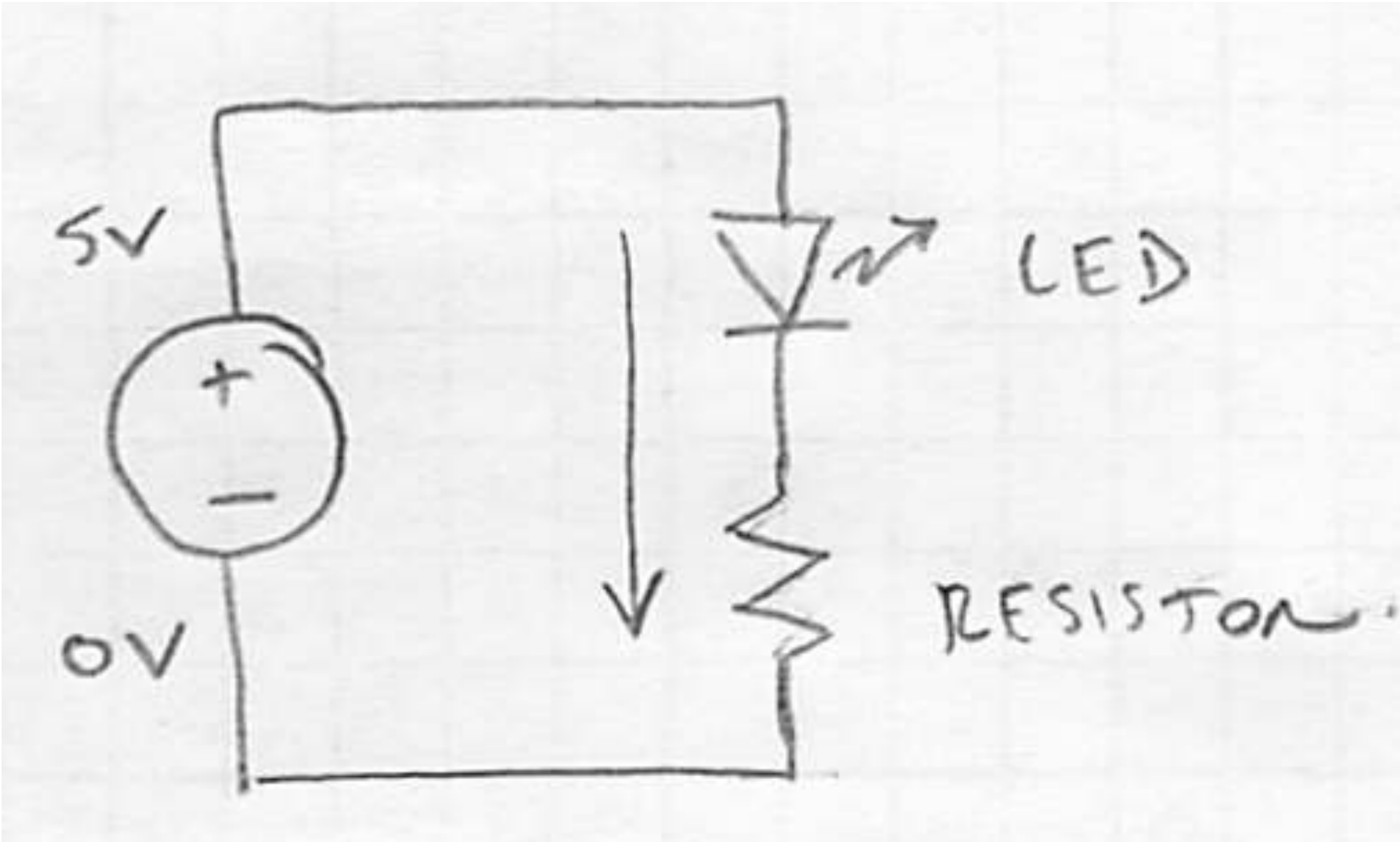
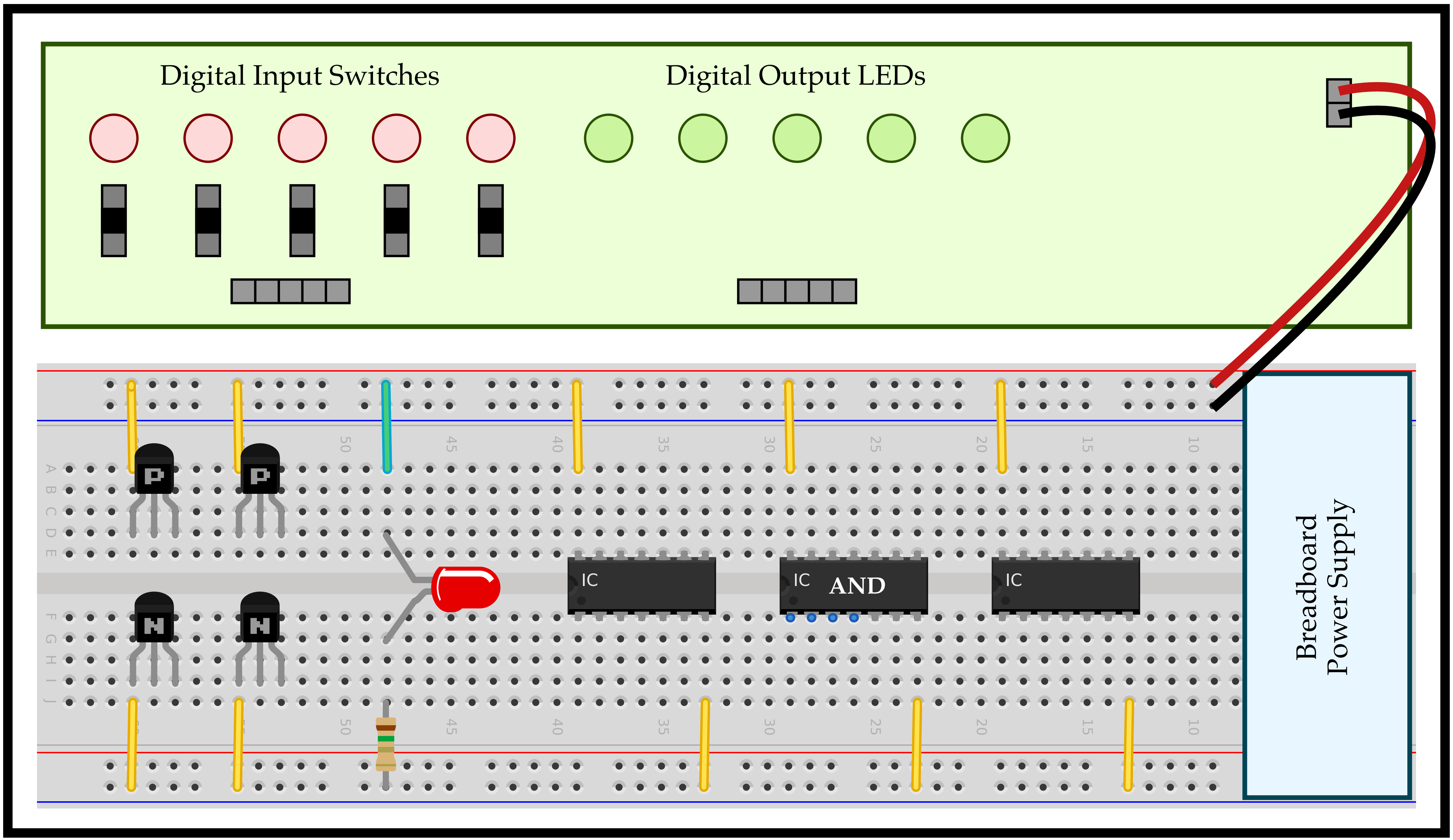
CURIE Lab 2

CURIE Lab 1

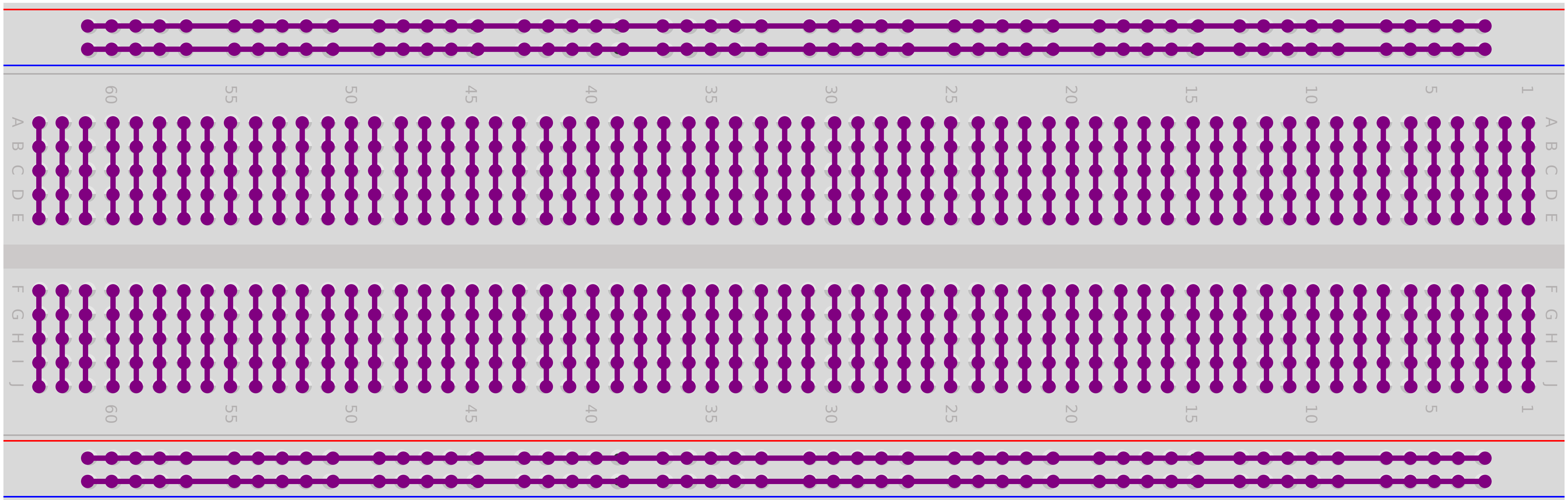
Simple LED Circuit



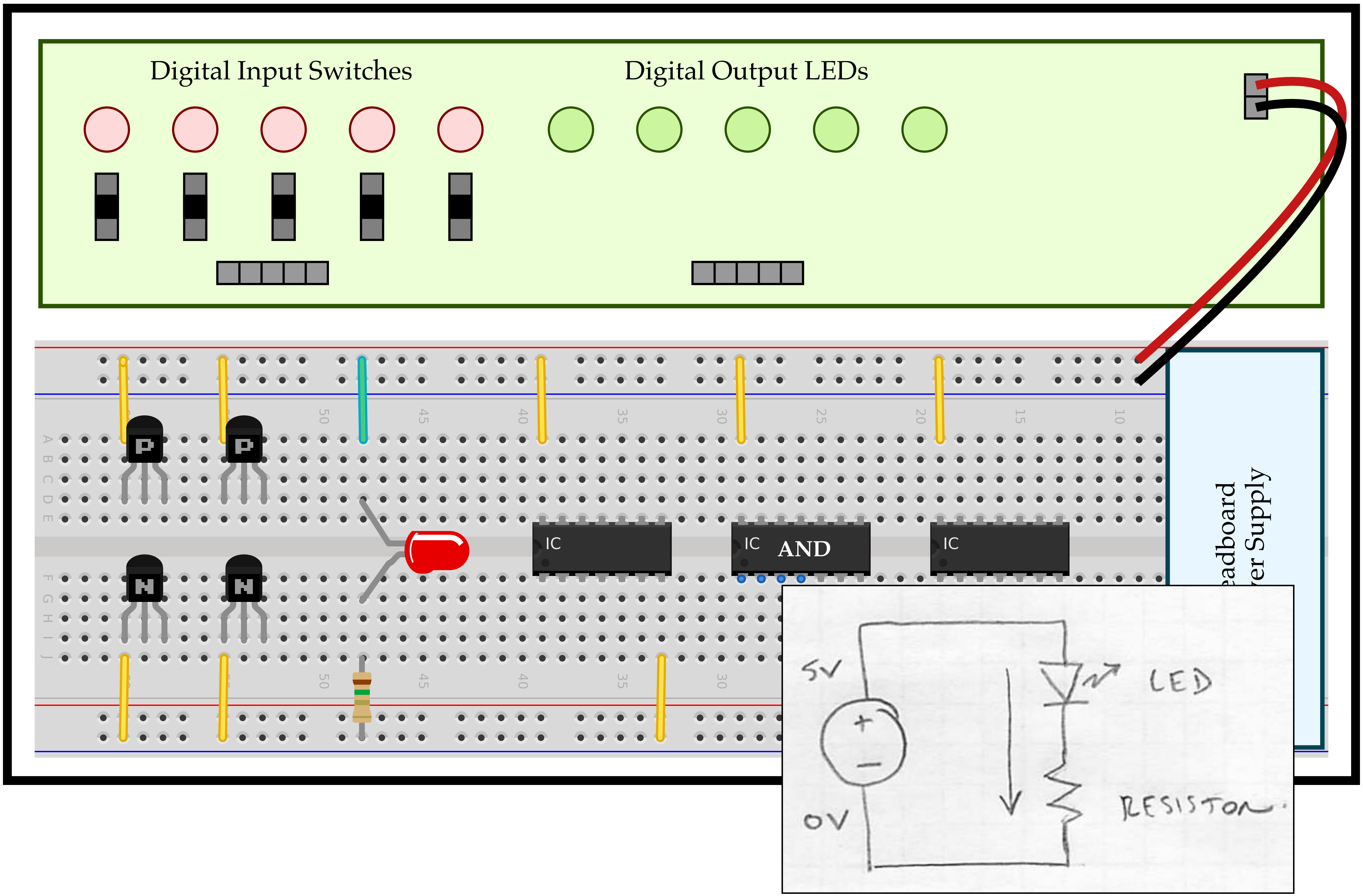
Breadboard Prototyping Platform



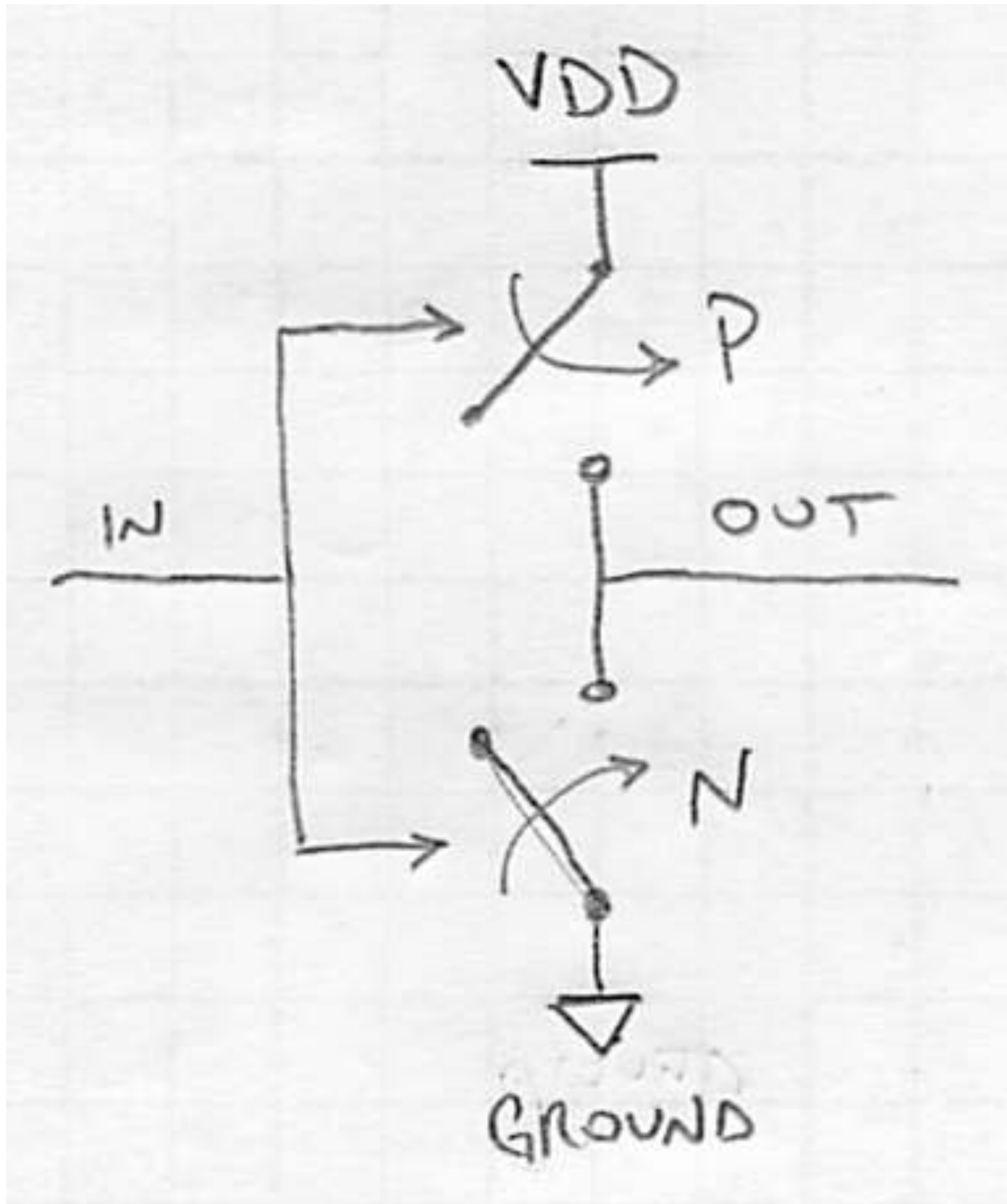
Connectivity Inside Breadboard



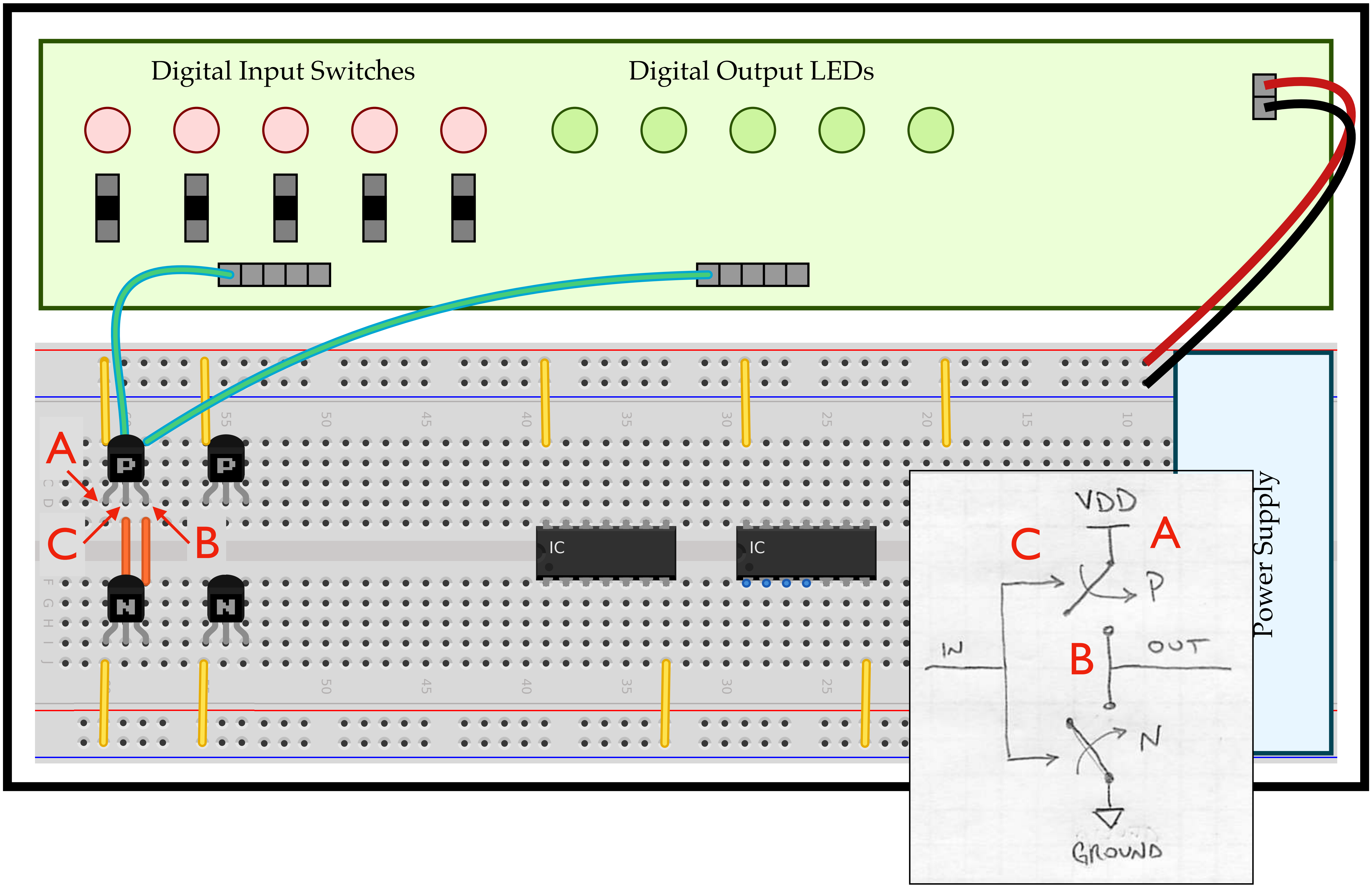
LED Circuit on Breadboard



Inverter Circuit



Inverter Circuit on Breadboard



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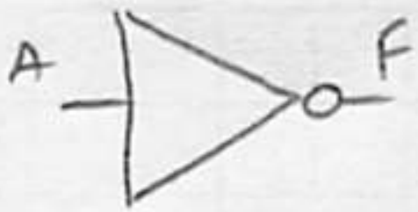
CURIE Lab 2

CURIE Lab 1

NOR, AND, OR, XOR Logic Gates

NOT



A	F
0	1
1	0

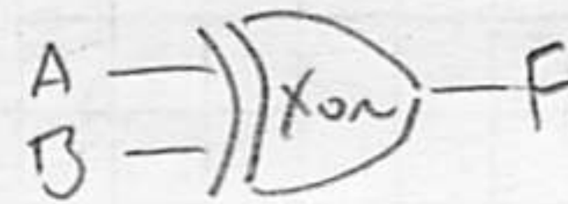
AND

A	B	F
0	0	0
0	1	0
1	0	0
1	1	1

OR

A	B	F
0	0	0
0	1	1
1	0	1
1	1	1

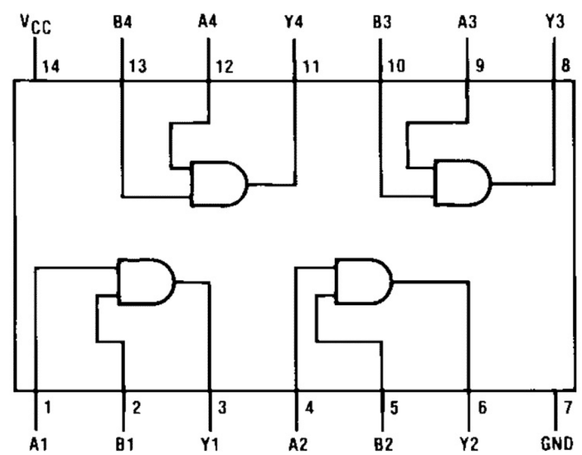
XOR



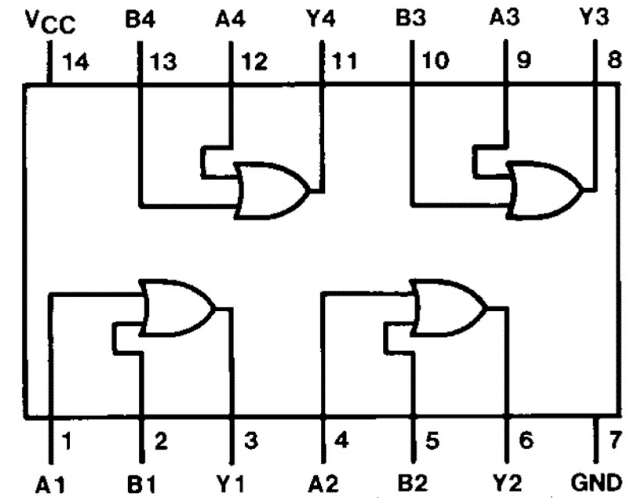
A	B	F
0	0	0
0	1	1
1	0	1
1	1	0

Logic Gates Implemented in Single Chip

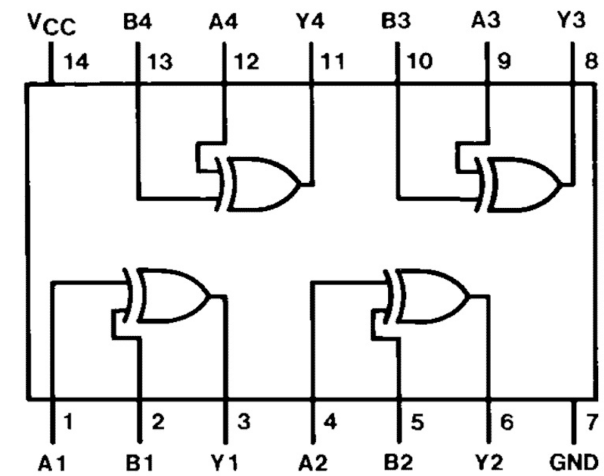
(a) Integrated Circuit



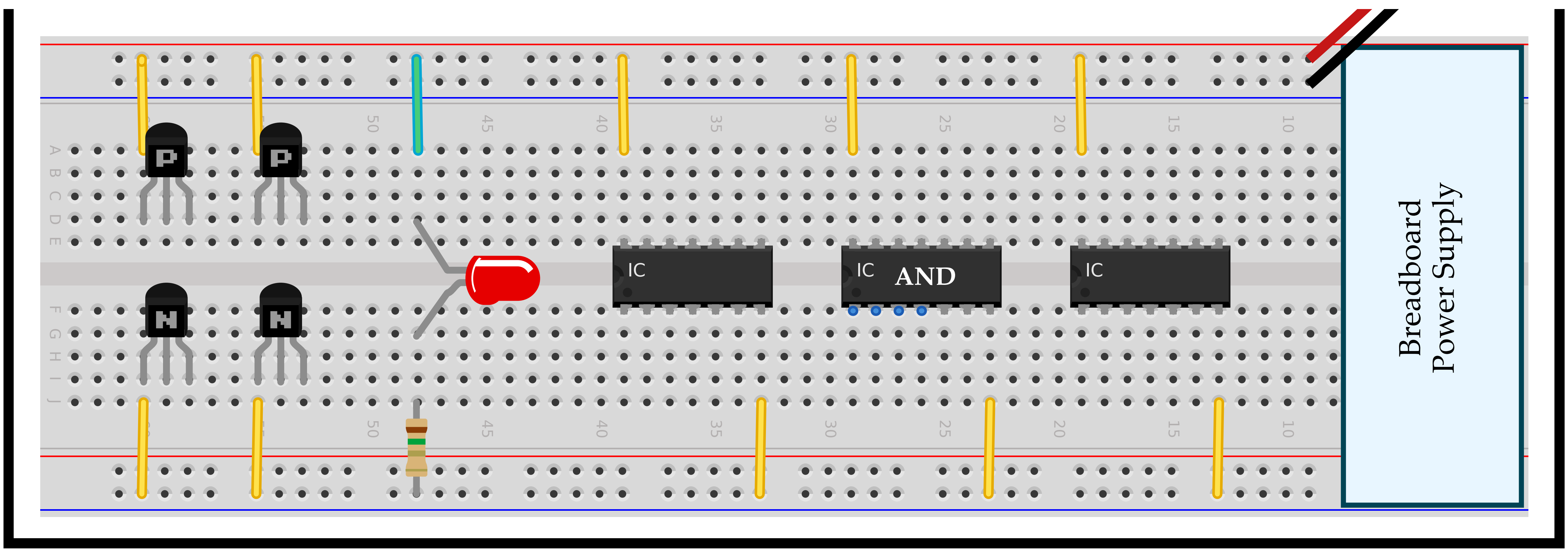
(b) AND Chip



(c) OR Chip



(d) XOR Chip



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CURIE Lab 2

CURIE Lab 1

Aside: Binary Arithmetic

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

Figure 12: Binary and Decimal Representation

```
Step 1  Step 2  Step 3  Step 4

            1      11      11
   011     011     011     011
+  110  +  110  +  110  +  110
------  ------  ------  ------
     1      01     001    1001
```

Figure 13: Example Using Binary Addition for 3+6

Half-Adder Unit: Add Two 1b Numbers

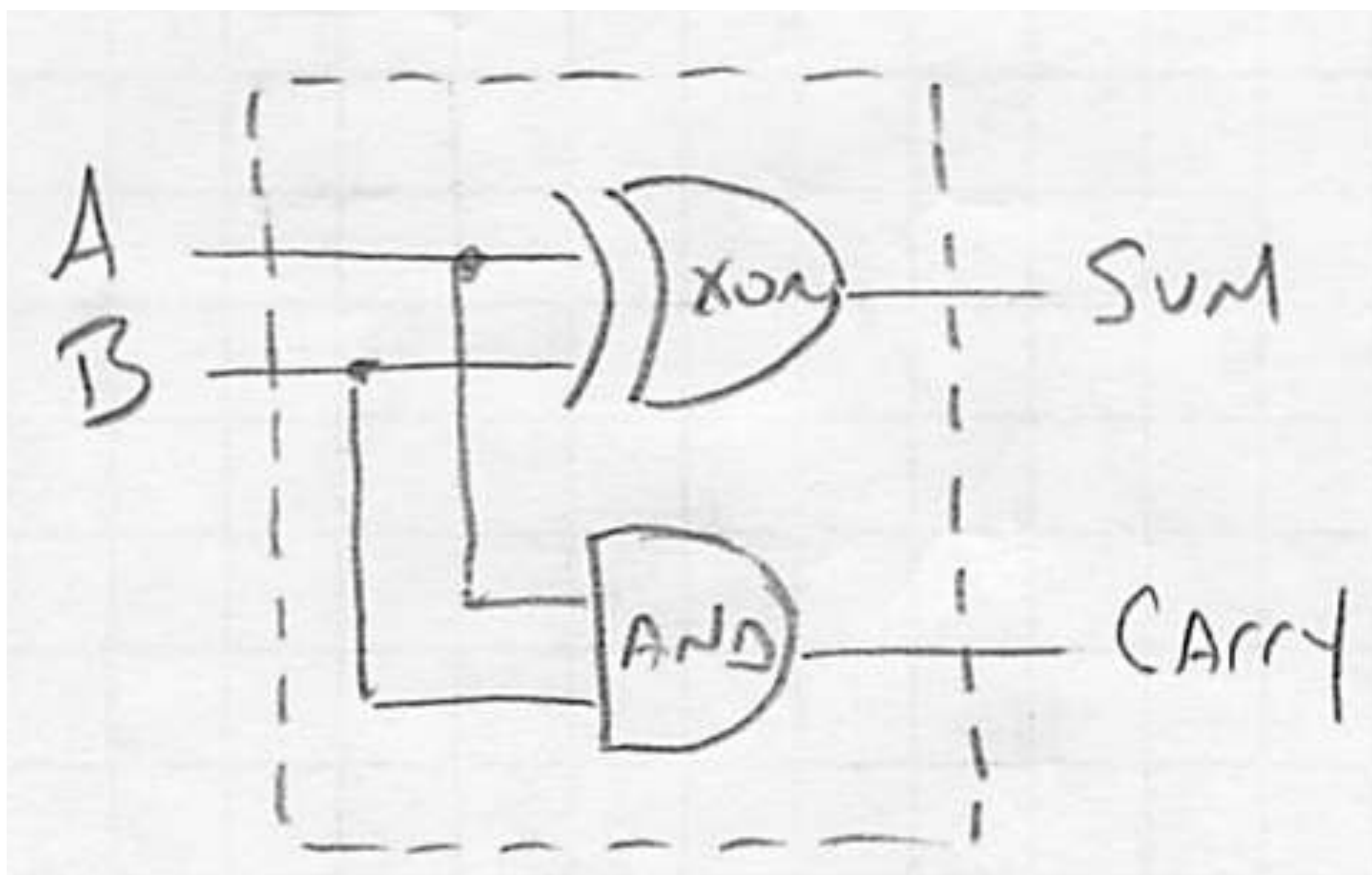
input A		input B		result base 10	result base 2	carry bit	sum bit
0	+	0	=	0	00	0	0
0	+	1	=	1	01	0	1
1	+	0	=	1	01	0	1
1	+	1	=	2	10	1	0

Figure 14: Four Possibilities when Adding Two One-Bit Numbers

input A	input B	sum bit
0	0	0
0	1	1
1	0	1
1	1	0

input A	input B	carry out
0	0	0
0	1	0
1	0	0
1	1	1

Figure 15: Truth Tables for Sum Bit and Carry Bit

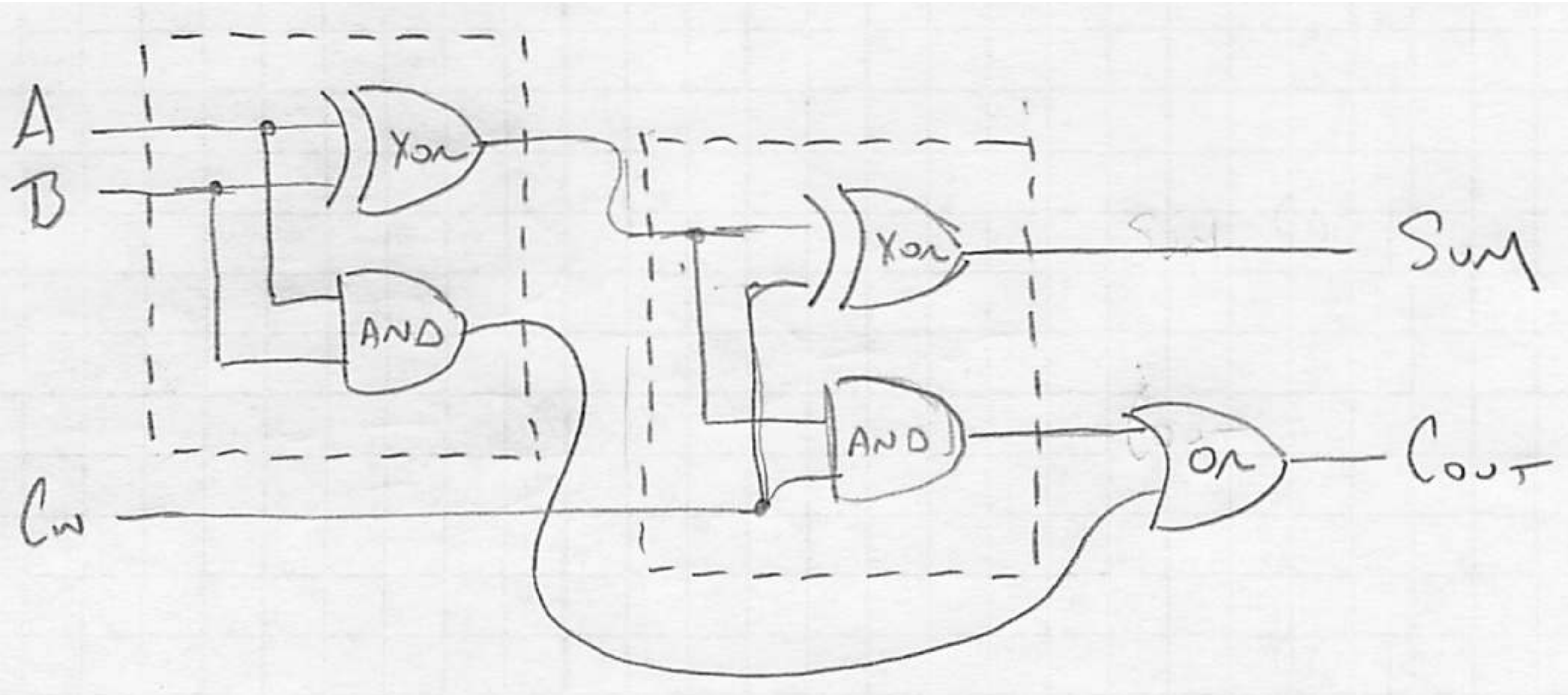


Full-Adder: Add Three 1b Numbers

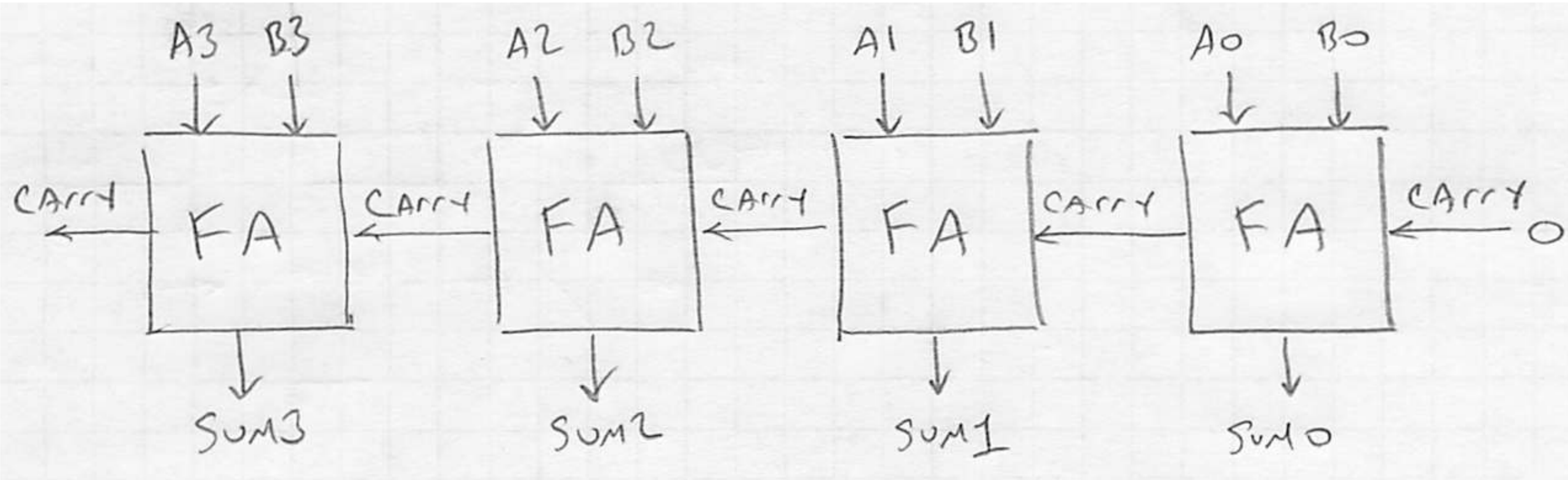
input A	input B	input C	result base 10	result base 2	carry bit	sum bit
0	+ 0	+ 0	= 0	00	0	0
0	+ 0	+ 1	= 1	01	0	1
0	+ 1	+ 0	= 1	01	0	1
0	+ 1	+ 1	= 2	10	1	0
1	+ 0	+ 0	= 1	00	0	0
1	+ 0	+ 1	= 2	10	1	0
1	+ 1	+ 0	= 2	10	1	0
1	+ 1	+ 1	= 3	11	1	1

Figure 17: Eight Possibilities when Adding Three One-Bit Numbers

Full-Adder: Add Three 1b Numbers



Ripple Carry Adder



Lab 1 Overview

- Part 1.A Experiment with LED
- Part 1.B Experiment with Inverters
- Part 1.C Develop NAND Gate
- Part 2.A Experiment with Logic Gates
- Part 2.B Develop Parity Checker
- Part 3.A Experiment with Half-Adder
- Part 3.B Develop Full-Adder
- Part 3.C Share Photo or Video of Full-Adder
- Experiment with multi-bit adder

Let's wire up a simple LED and inverter circuit