Intro to Electronics

Week 5

Build a Larson scanner (red moving Cylon eye)

TODAY’S PROJECT

Analog vs. digital

- Continuous range of voltages
  - Can use any value within certain limits
  - More susceptible to noise
- Useful for sound, light, sensing, etc.

- Two voltages — high and low
  - Can only use these two values (0 and 1)
  - Can lose some information
- Useful for data storage, processing, etc.

Analog vs. digital

- Continuous range of voltages
  - Can use any value within certain limits
  - More susceptible to noise
- Useful for sound, light, sensing, etc.

- Two voltages — high and low
  - Can only use these two values (0 and 1)
  - Can lose some information
- Useful for data storage, processing, etc.

- Plenty of reasons to use both!

Digital logic

- We'll focus here on digital
- Started with this a couple of weeks ago
  - Mainly talked about logic gates

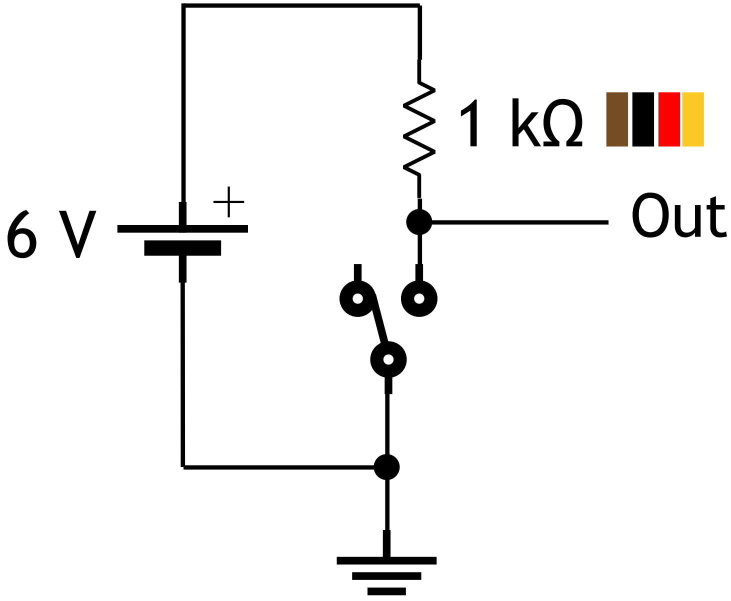
Digital logic

- More complex parts exist than just gates:
  - Multiplexers
    - Use one signal to control several outputs
  - Latches
    - Fundamental storage element — store a bit at a time
  - Adders, multipliers
    - Mathematical elements (add/multiply numbers)
  - etc.

Making zeroes and ones

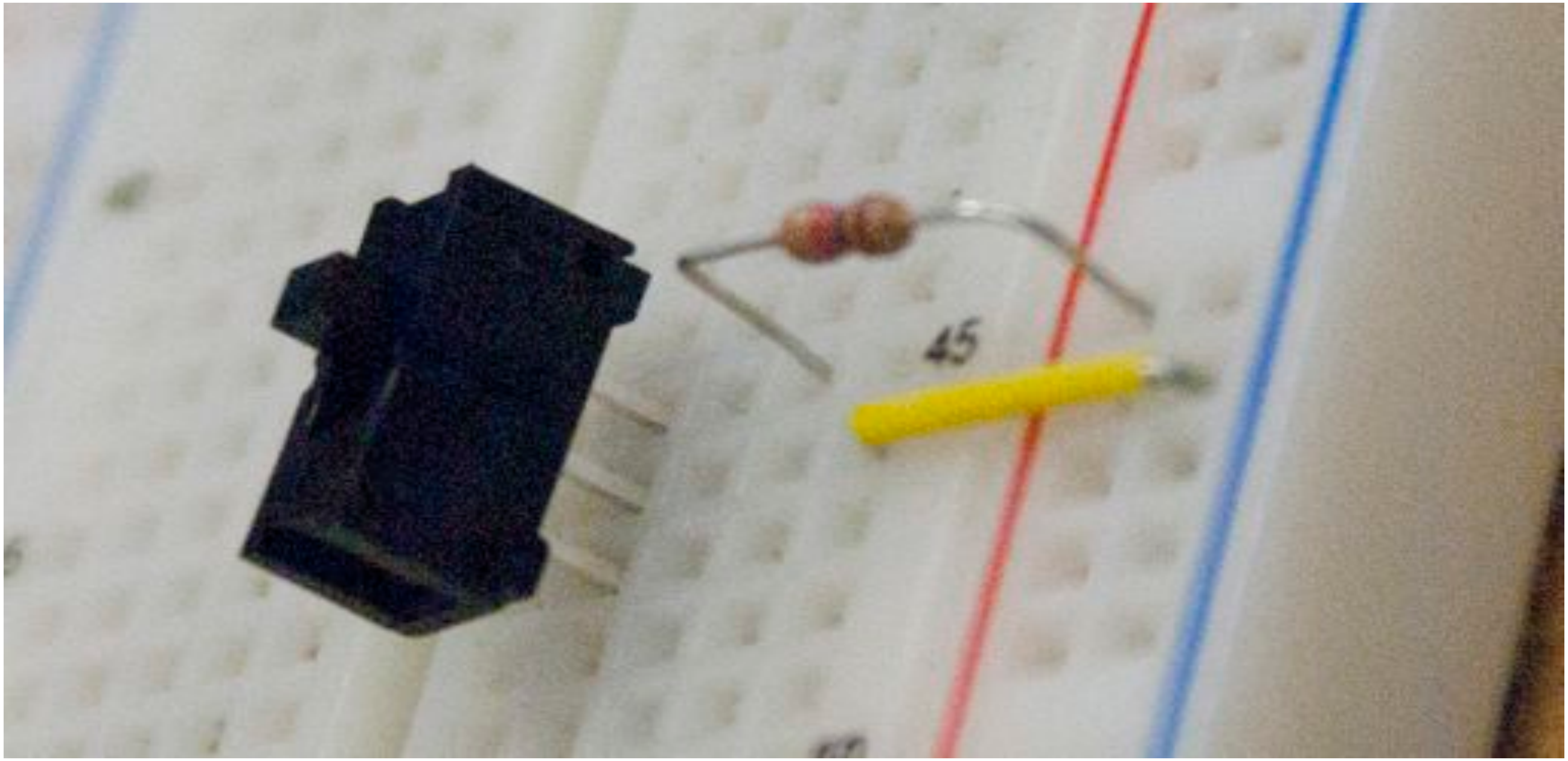
- Need to hold stable high and low voltages
- How do we do that?
  - Already know how to set a high *or* low voltage
    - Use a switch to connect something to either positive or negative

Pull-up resistor



- When switch is connected, output is 0 V (low)
- When switch is disconnected, output is ~6 V (high)
- Avoids “floating” (unpredictable) output

Pull-up resistor



Pull-up resistor

- Measure it with a multimeter!
  - Watch the voltage between the negative end of the batteries and the leg of the resistor that connects to the switch
  - Note the difference at different positions of the switch

Decimal counter

- New component!
- Ten (main) outputs
  - We'll refer to them as outputs 0 through 9
- One (main) input
  - Called the "clock"

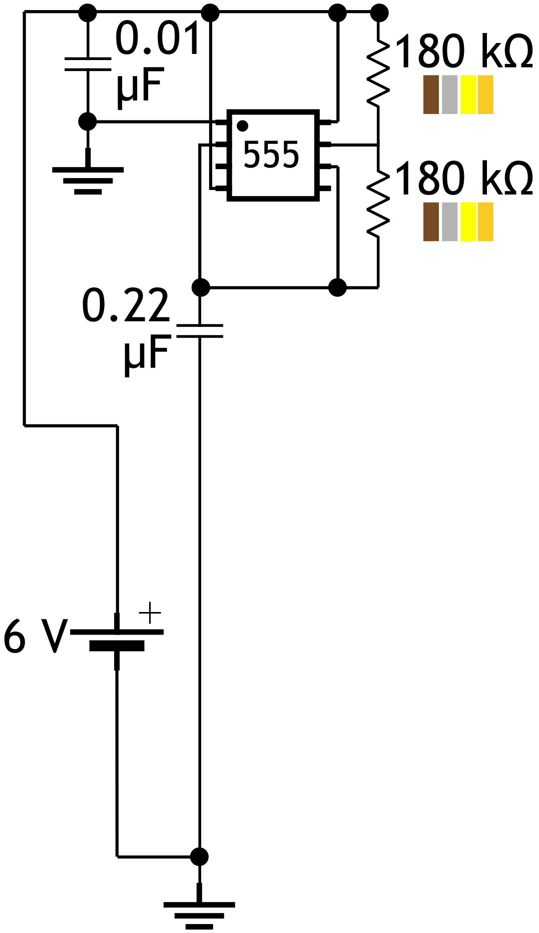
Decimal counter

- Clock oscillates (goes back and forth)
- Each time it goes high:
  - The currently active output turns off
  - The next output turns on
- Counts from 0 to 9 and then loops back to 0
  - Like a wheel in an old odometer

What works as a clock?

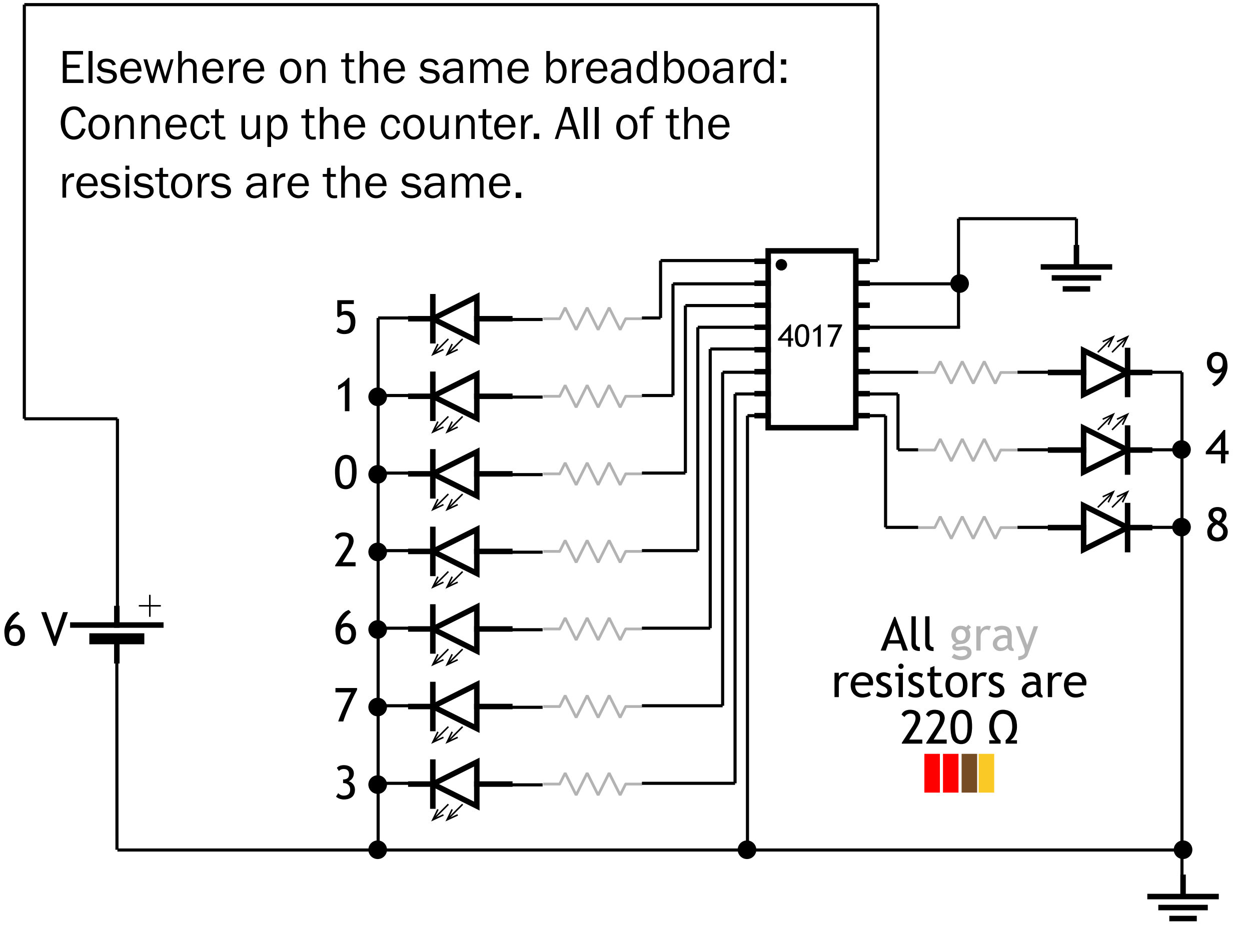
- Anything that alternates between high and low
    - – Quartz crystals
    - – Resonant LC networks
    - – Part of your credit cards' magnetic stripes
    - – 555 timer outputs!

Let’s try it



Just the clock first:
This is same 555 circuit as last week, just with different resistors (and therefore a different frequency).

Let’s try it



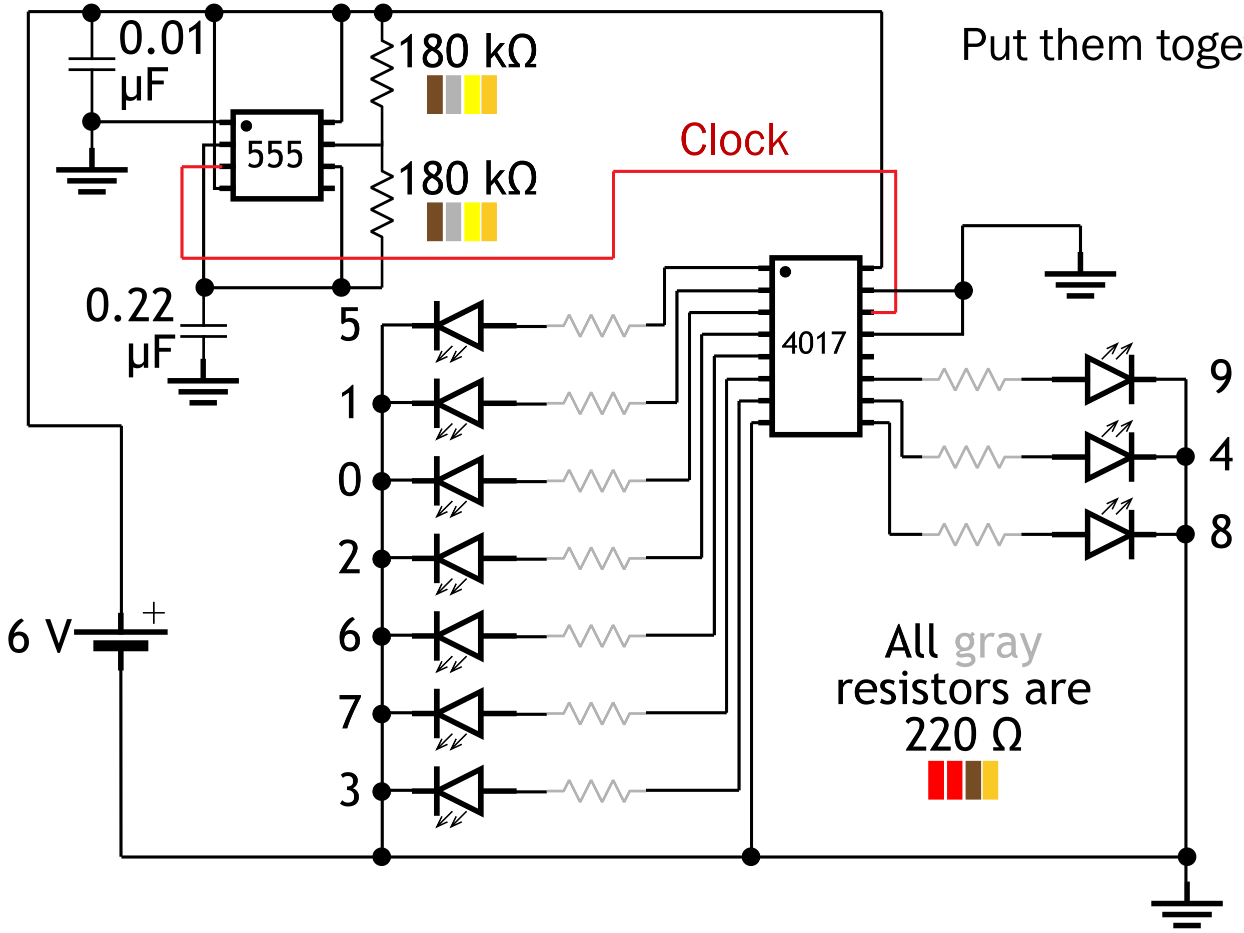
Elsewhere on the same breadboard: Connect up the counter. All of the resistors are the same.

LEDs (just to show which output’s on)

All gray resistors are 220 Ω

🟥🟥🟫🟨

Let’s try it

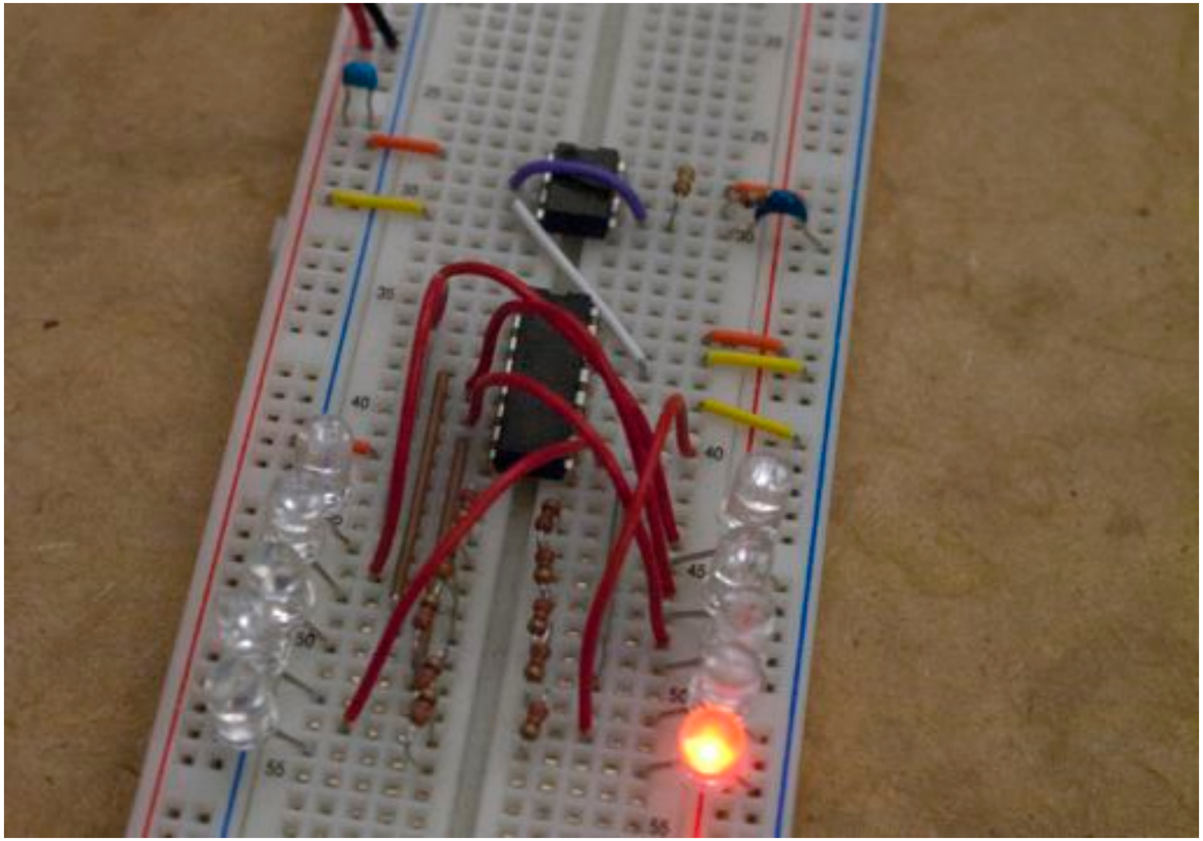


Put them together!

LEDs (just to show which output’s on)

All gray resistors are 220 Ω

Let’s try it



What now?

- We have a sequence of flashing lights
- Can we make them go in a line back and forth?

Make a table!

- Let’s use six LEDs instead of 10
- At each step, let’s pick which LED turns on

Step (output)	Which LED to light?
0	0 ●○○○○○
1	1 ○●○○○○
2	2 ○○●○○○
3	3 ○○○●○○
4	4 ○○○○●○
5	5 ○○○○○●
6	4 ○○○○●○
7	3 ○○○●○○
8	2 ○○●○○○
9	1 ○●○○○○

Make another table!

Step (output)	LED	
0	0	●○○○○○
1	1	○●○○○○
2	2	○○●○○○
3	3	○○○●○○
4	4	○○○○●○
5	5	○○○○○●
6	4	○○○○●○
7	3	○○○●○○
8	2	○○●○○○
9	1	○●○○○○

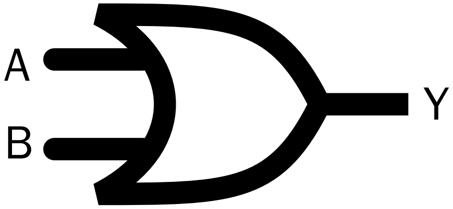
LED	Steps when it should be on
0	0
1	1 or 9
2	2 or 8
3	3 or 7
4	4 or 6
5	5

This or that

- Need some way to say “when A or B is on, make Y turn on as well”

This or that

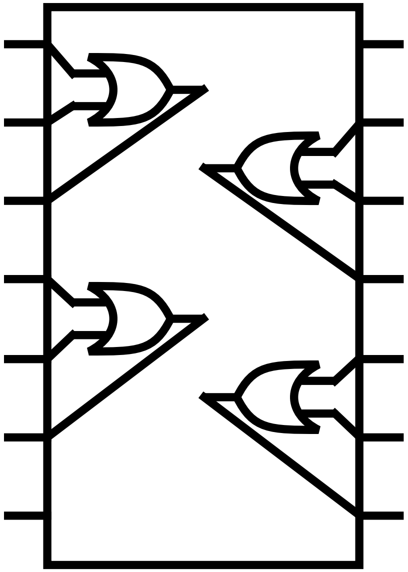
- Already got one: the OR gate



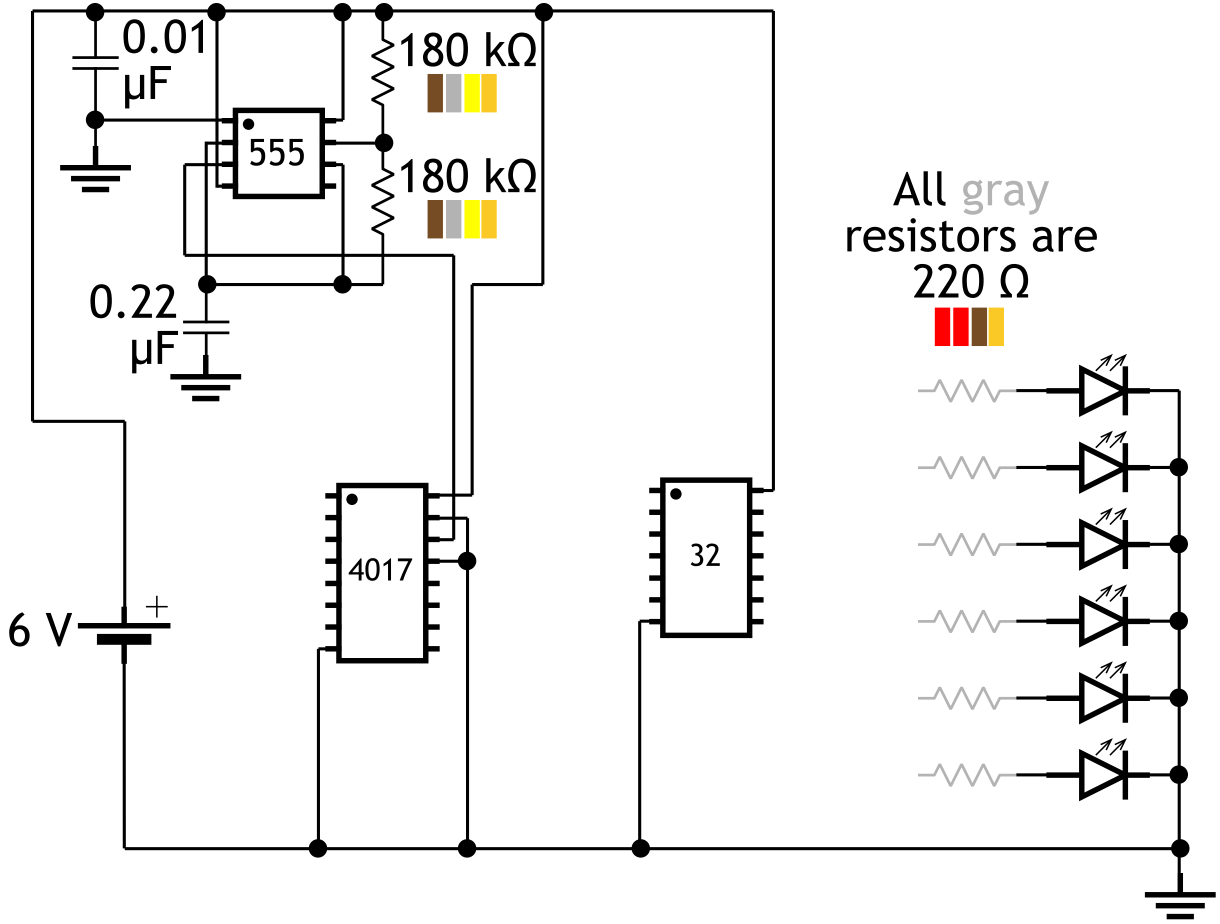
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

OR gate chip (74HC32)

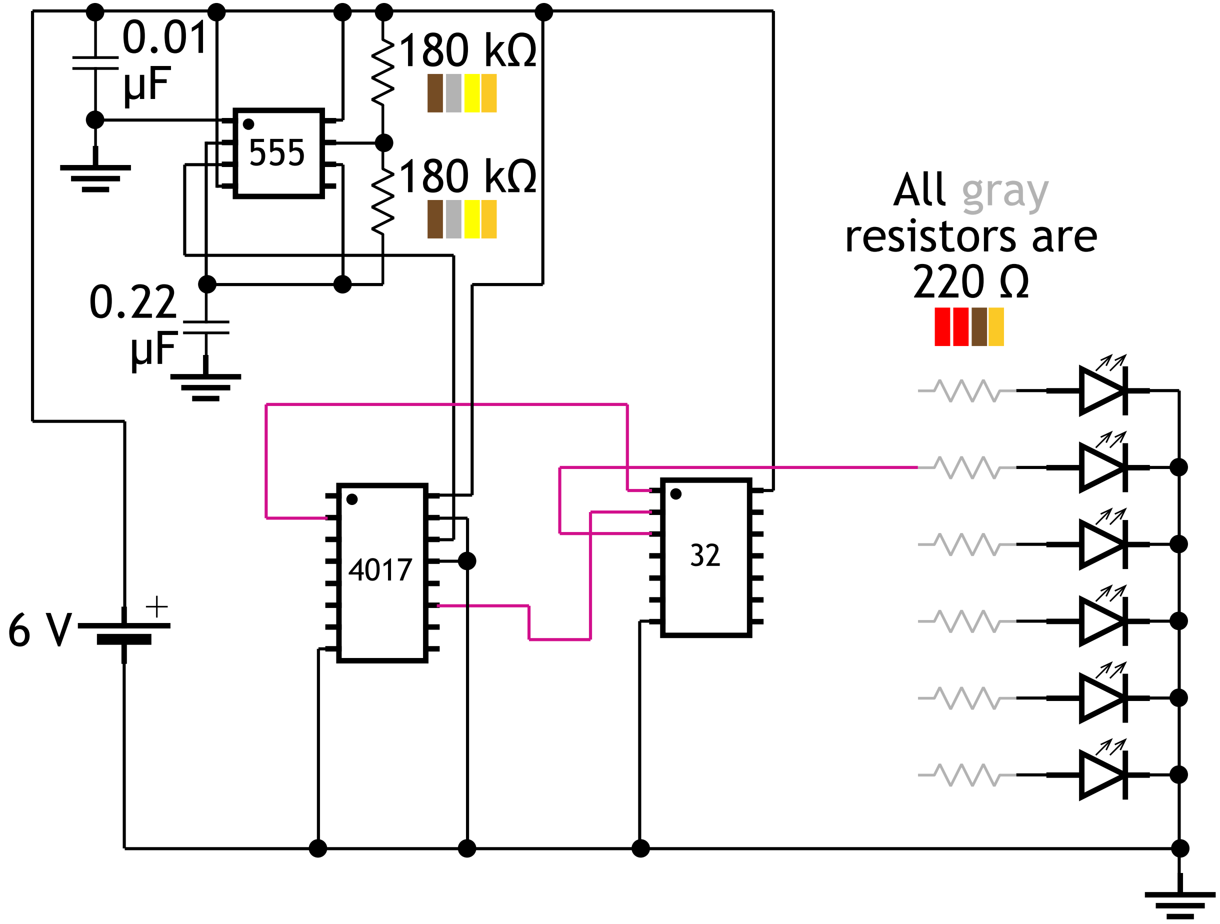
- Has four OR gates built in
  - How handy — we need four of them



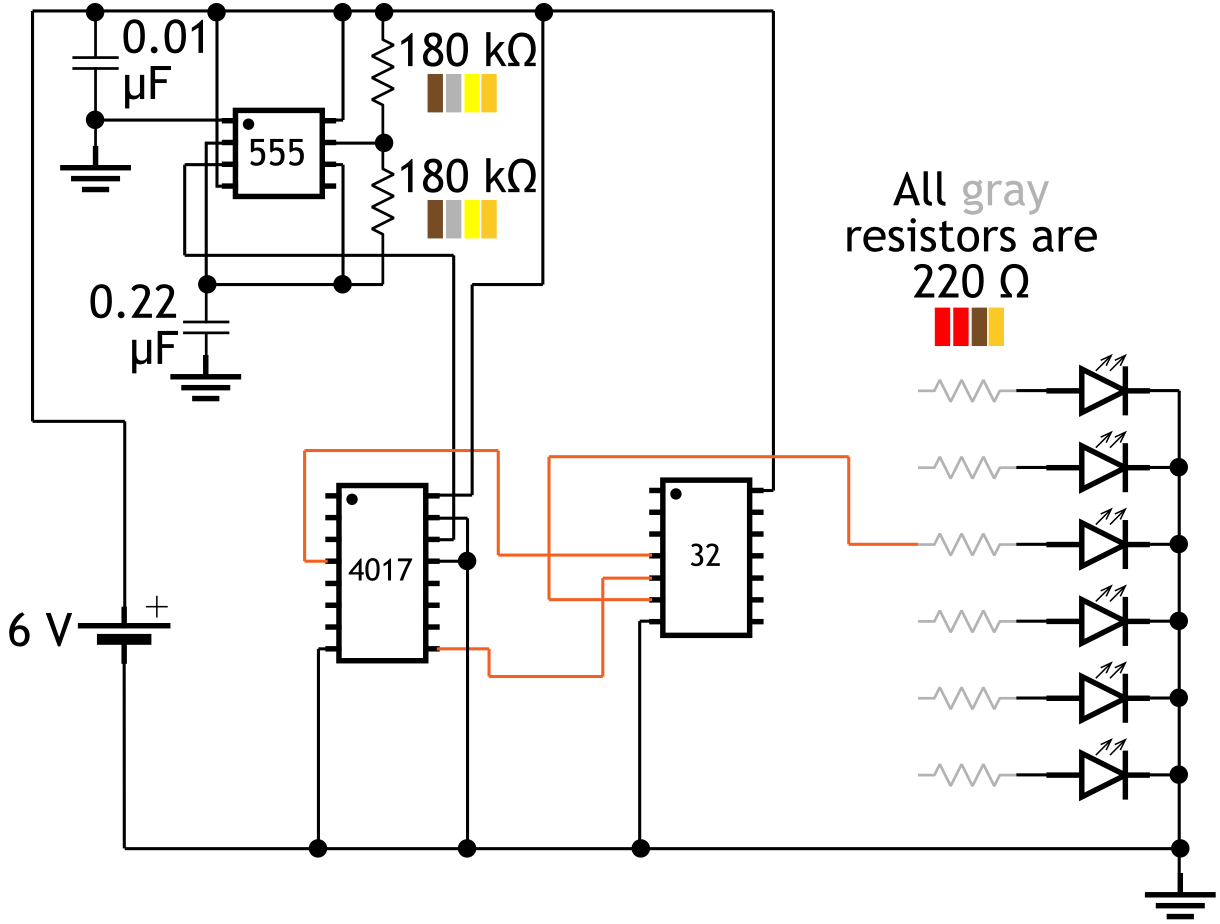
The setup


0.01 μF
555
180 kΩ
180 kΩ
0.22 μF
6 V
+
4017
32
All gray resistors are 220 Ω

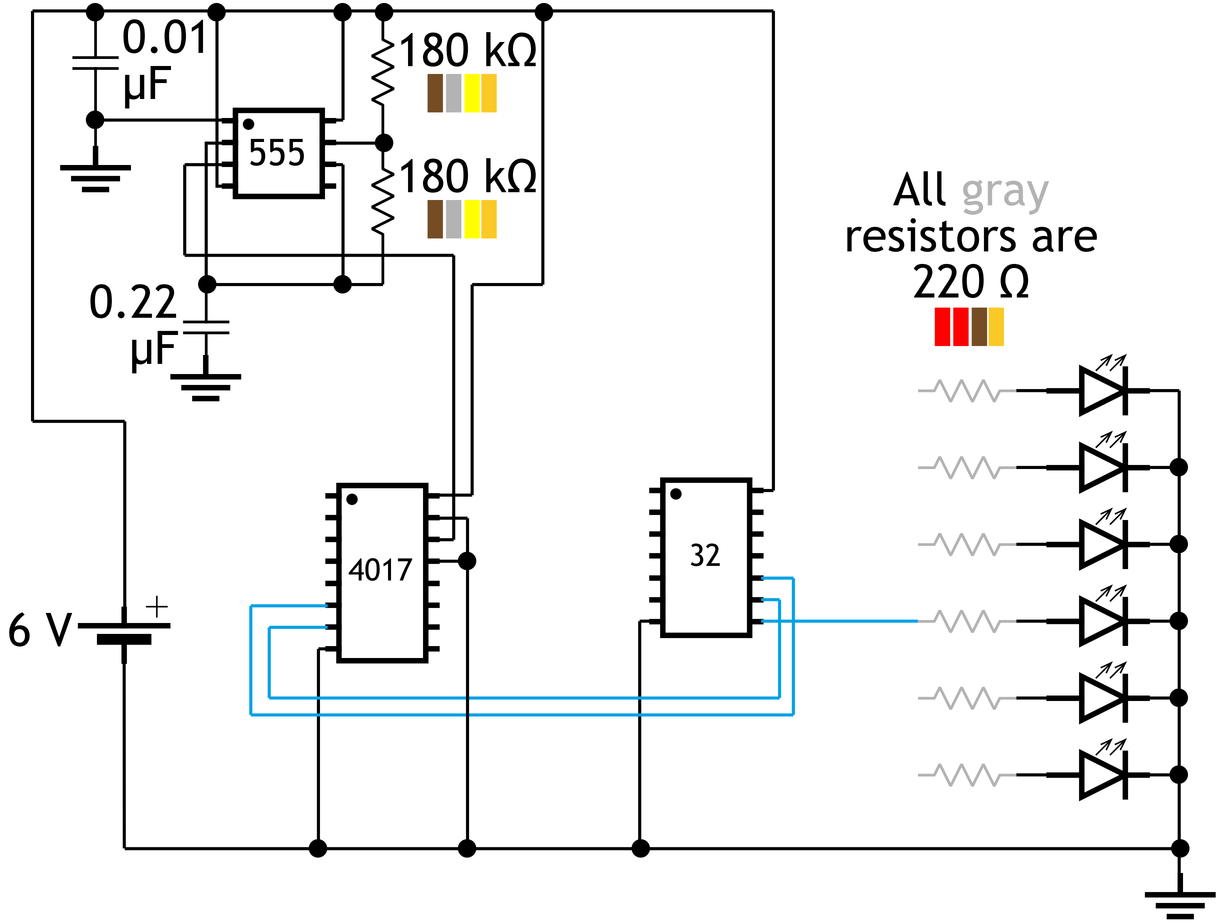
LED 1


0.01 µF
555
180 kΩ
180 kΩ
0.22 µF
6 V
+
4017
32
All gray resistors are 220 Ω

LED 2

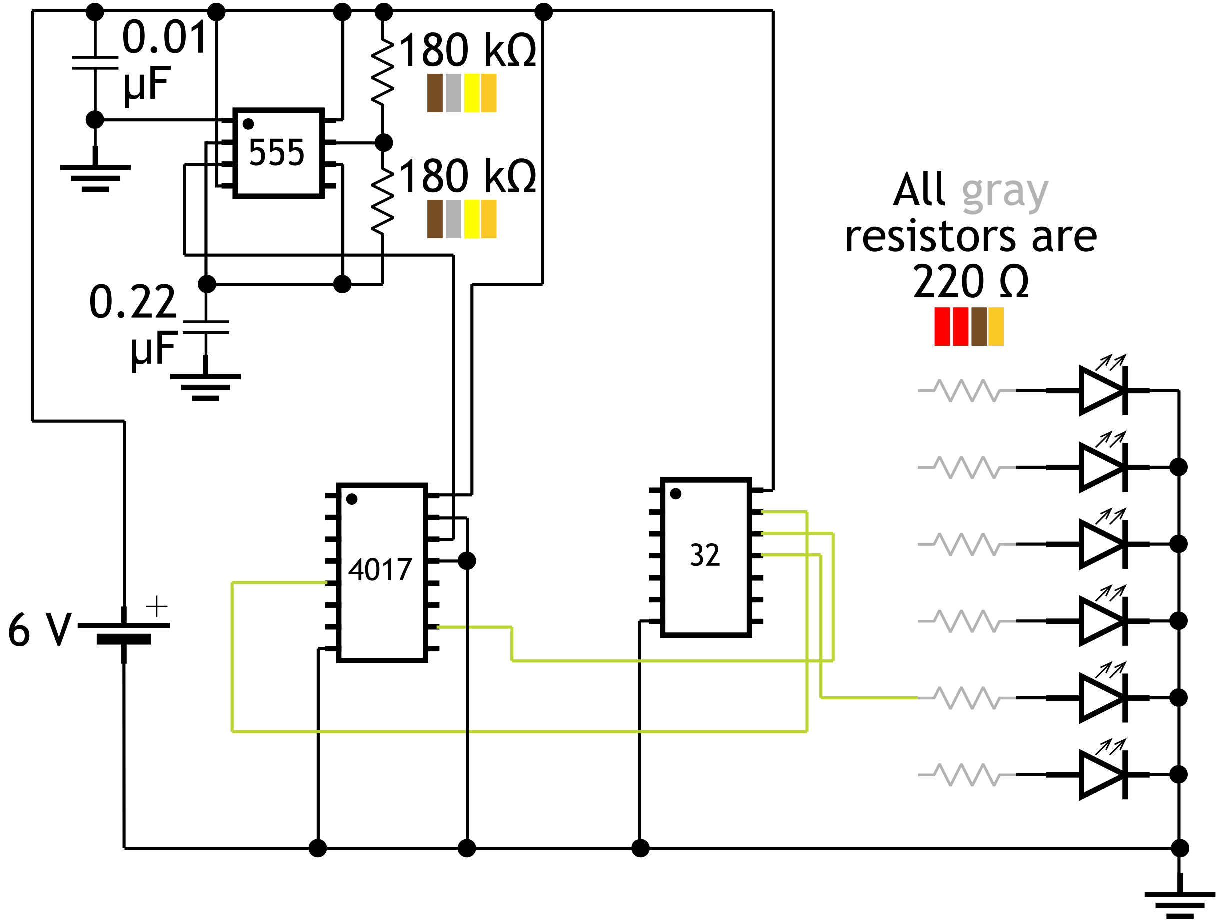

0.01 µF
180 kΩ
555
180 kΩ
0.22 µF
6 V
+
4017
32
All gray resistors are 220 Ω

LED 3



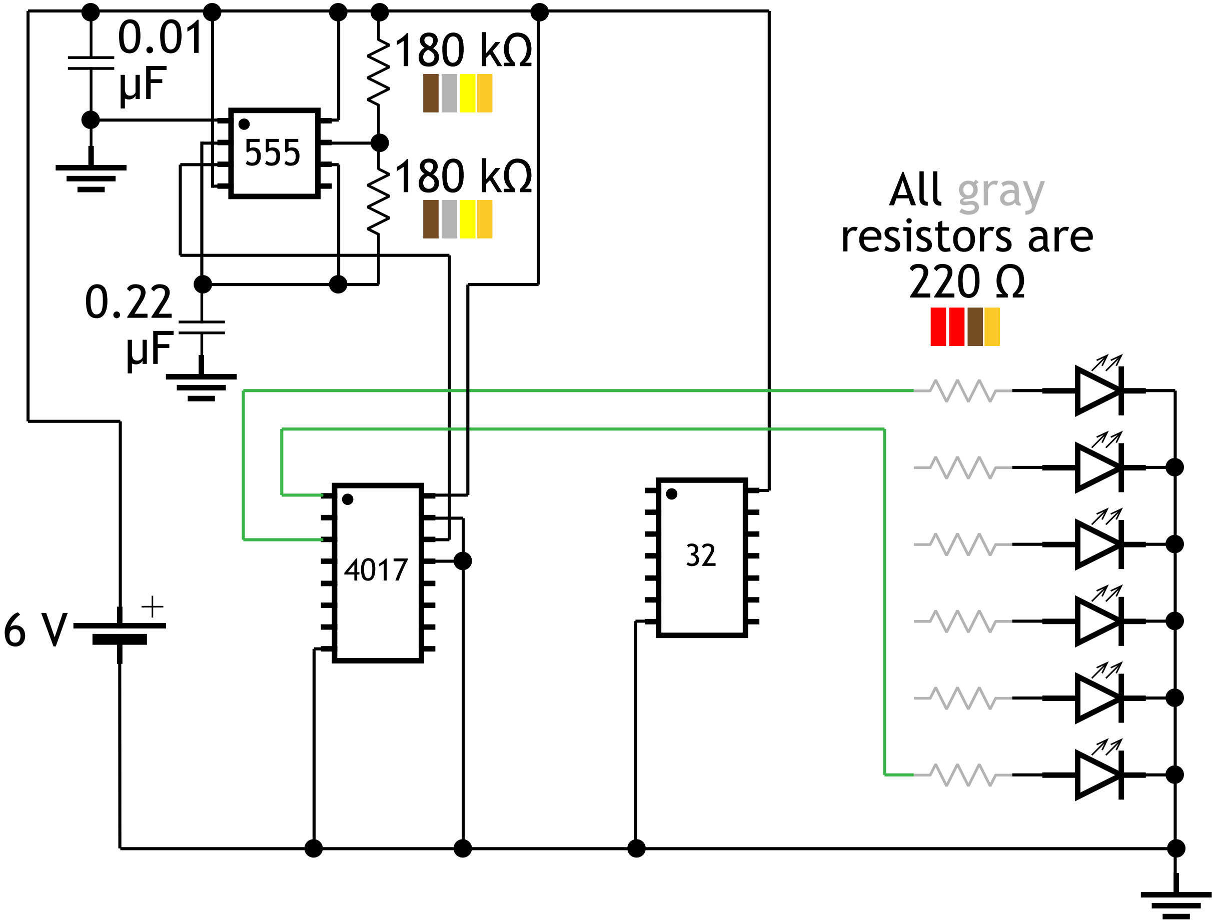
All gray resistors are 220 Ω

LED 4

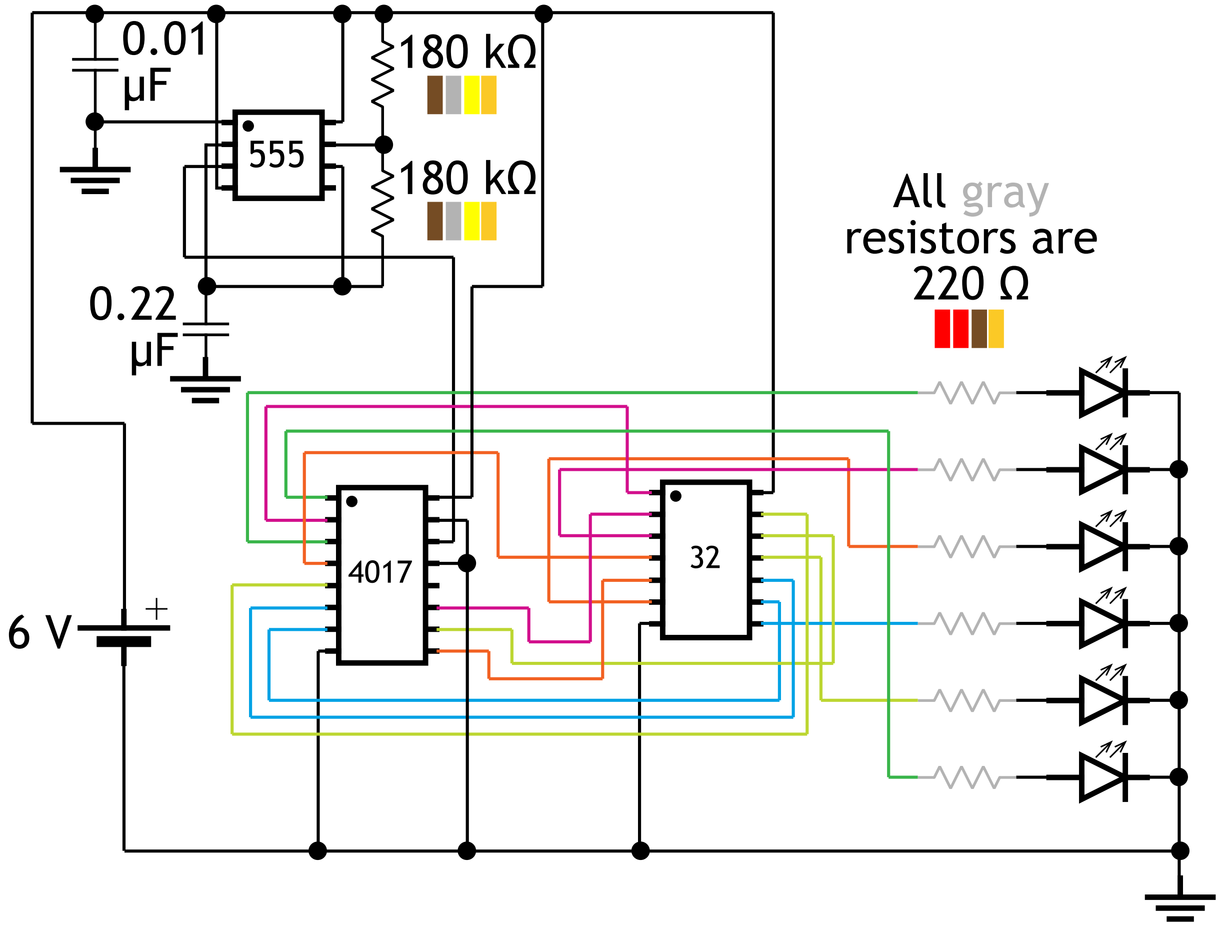


All gray resistors are 220 Ω

LEDs 0 and 5

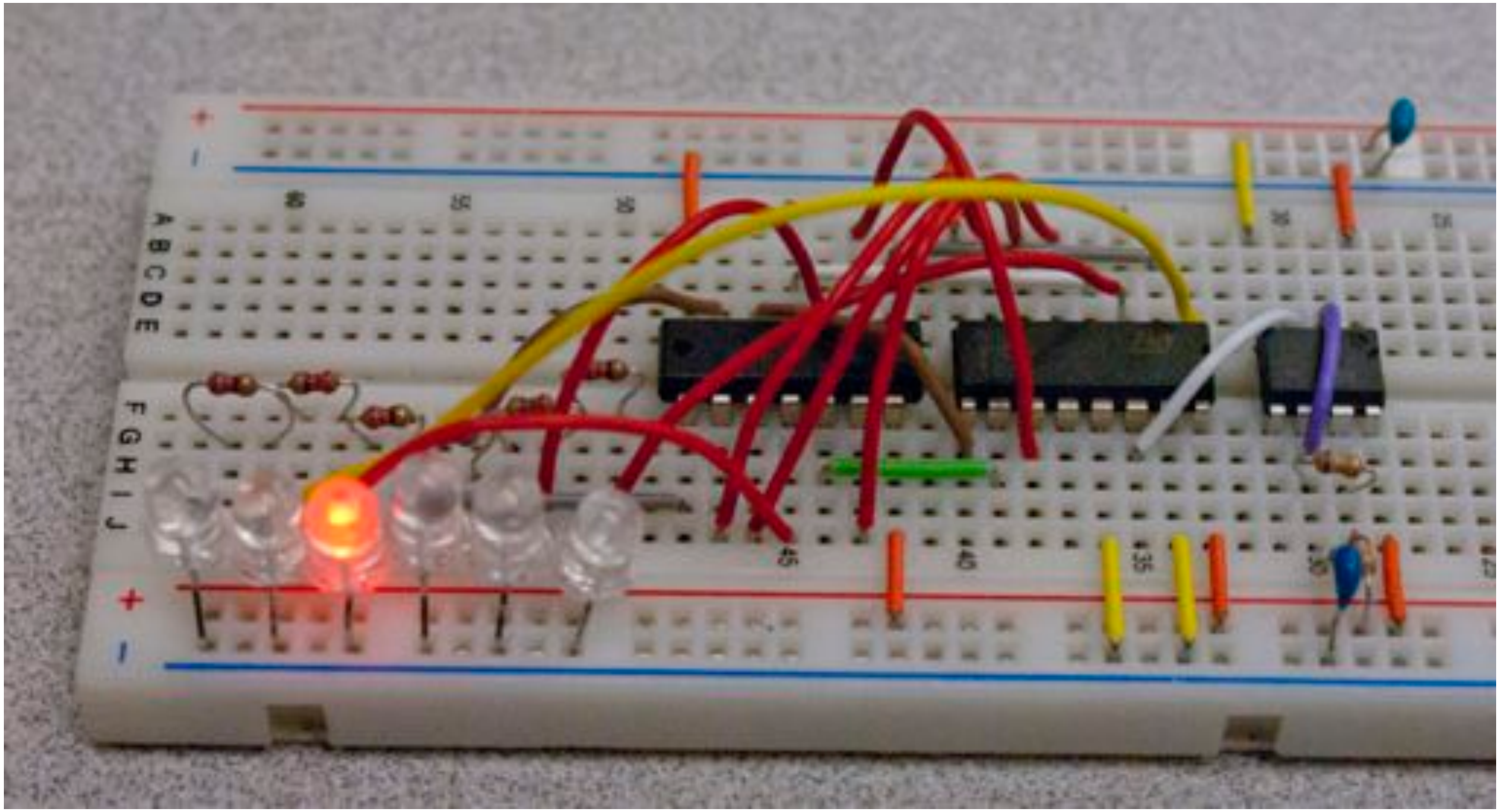

0.01 μF
555
180 kΩ
180 kΩ
0.22 μF
6 V
+
4017
32
All gray resistors are 220 Ω

Done!



All gray resistors are 220 Ω

Done!



That’s everything!

- Thanks again for coming to the class!