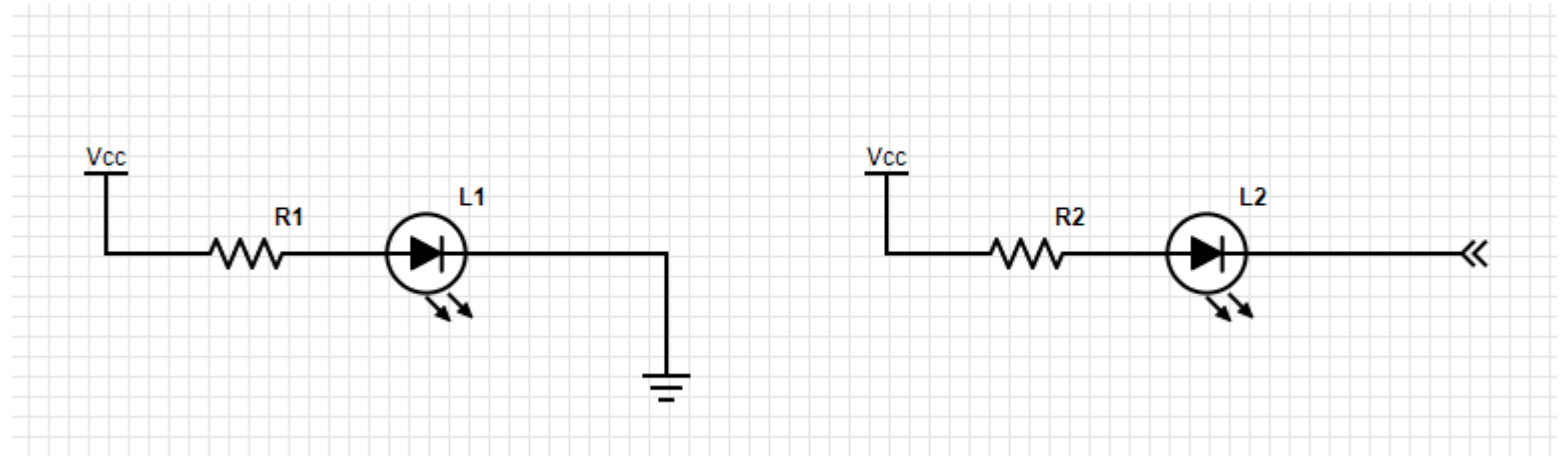
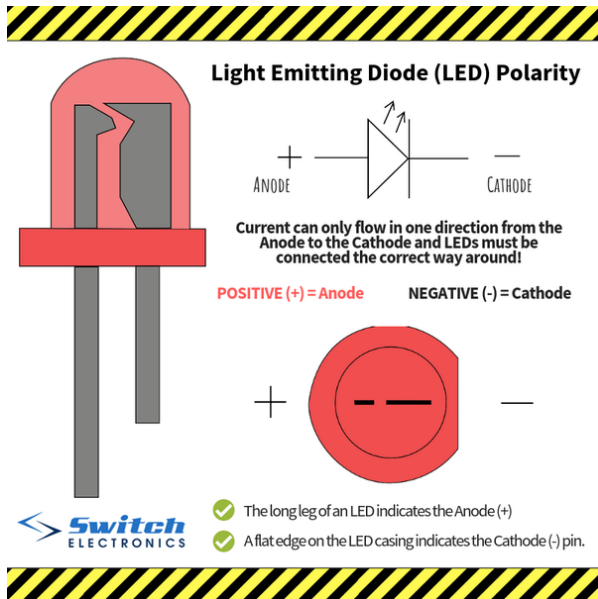


Digital Read/Write
ToF 센서

목표

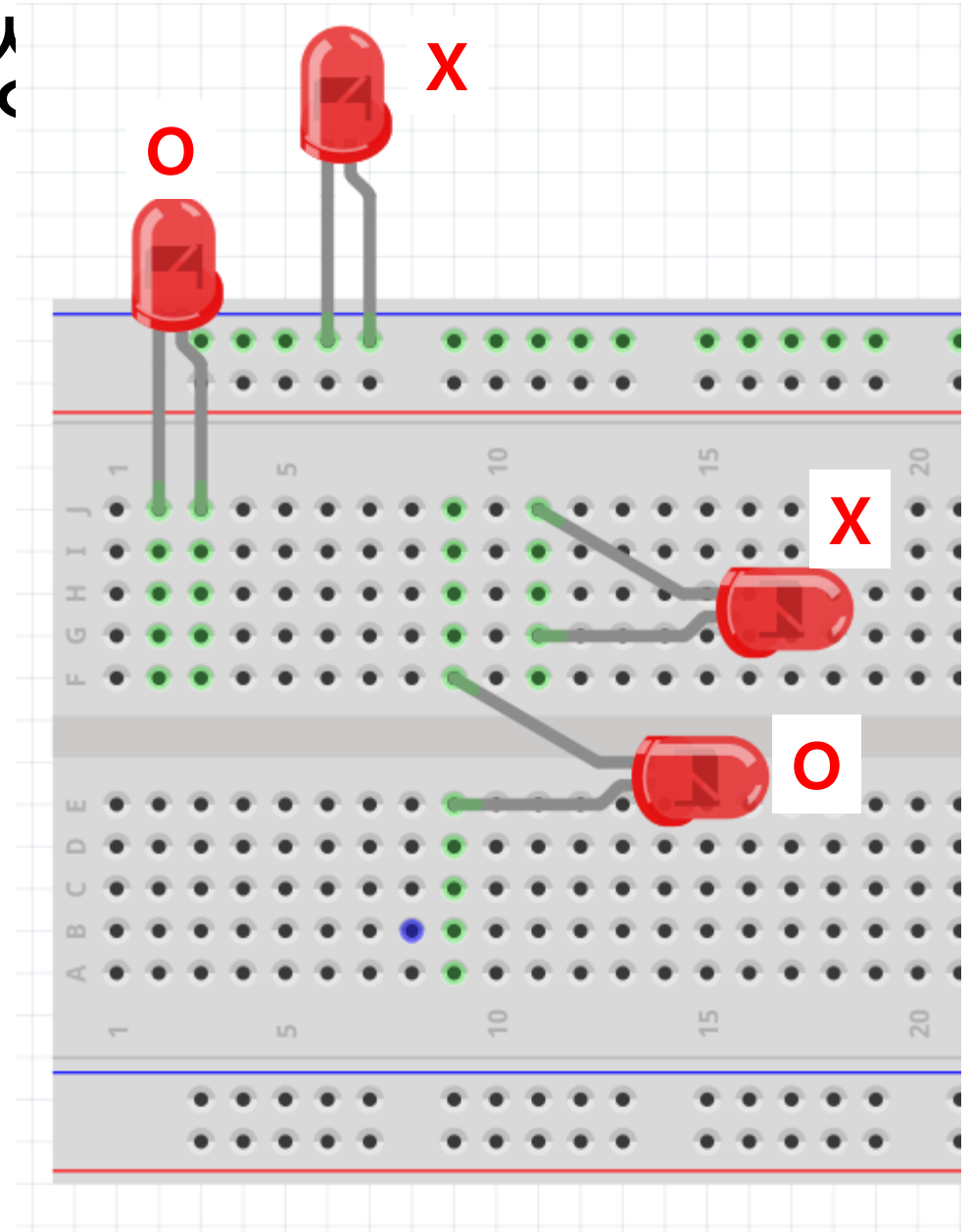
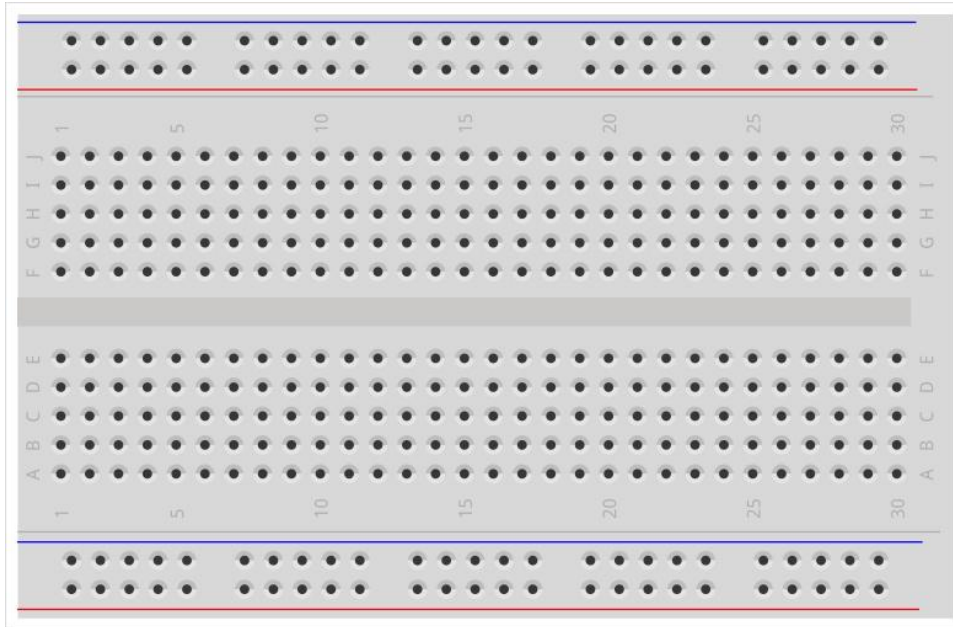
- 아두이노의 Digital 출력 실험
- 아두이노의 Digital 입력 실험
- On/Off 스위치 센서 실험 및 릴레이의 이해
- ToF의 이해 및 초음파를 이용한 거리 측정 실험

아두이노 개발 환경 구성 및 LED 테스트



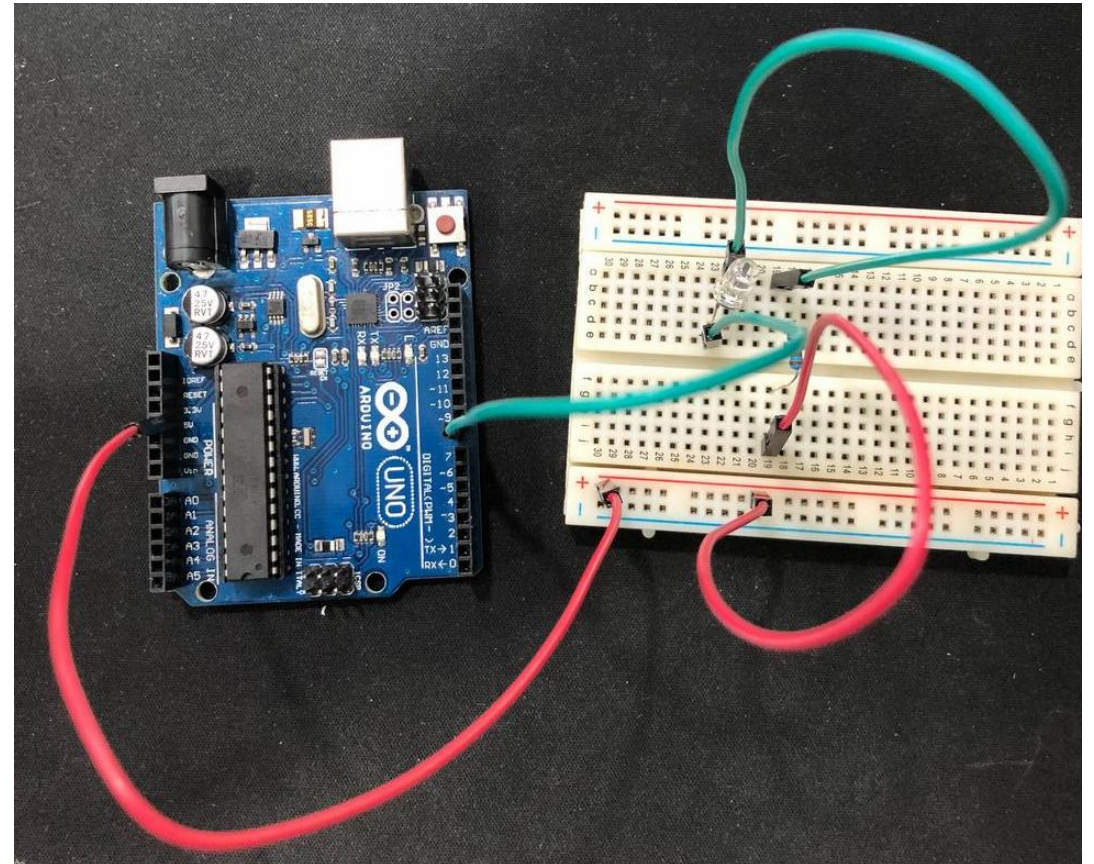
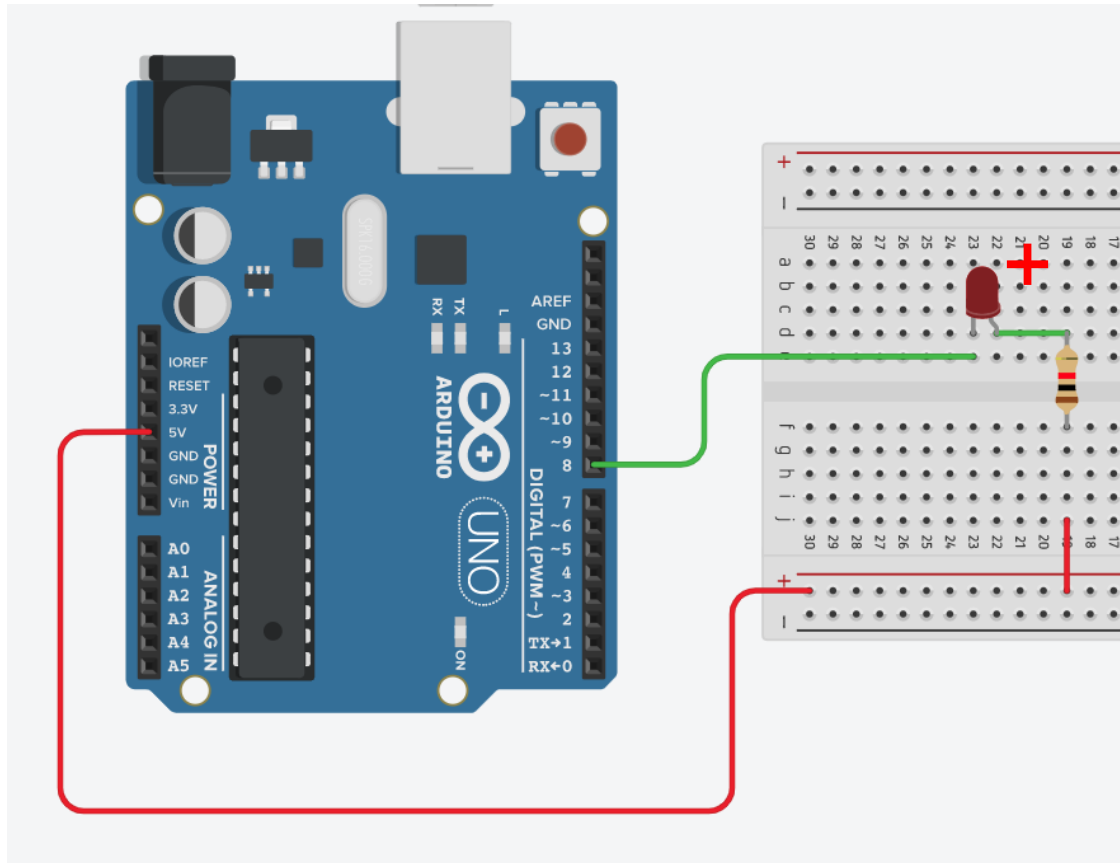
아두이노 개발 환경 구성

- 빵판 사용법(브레드보드)



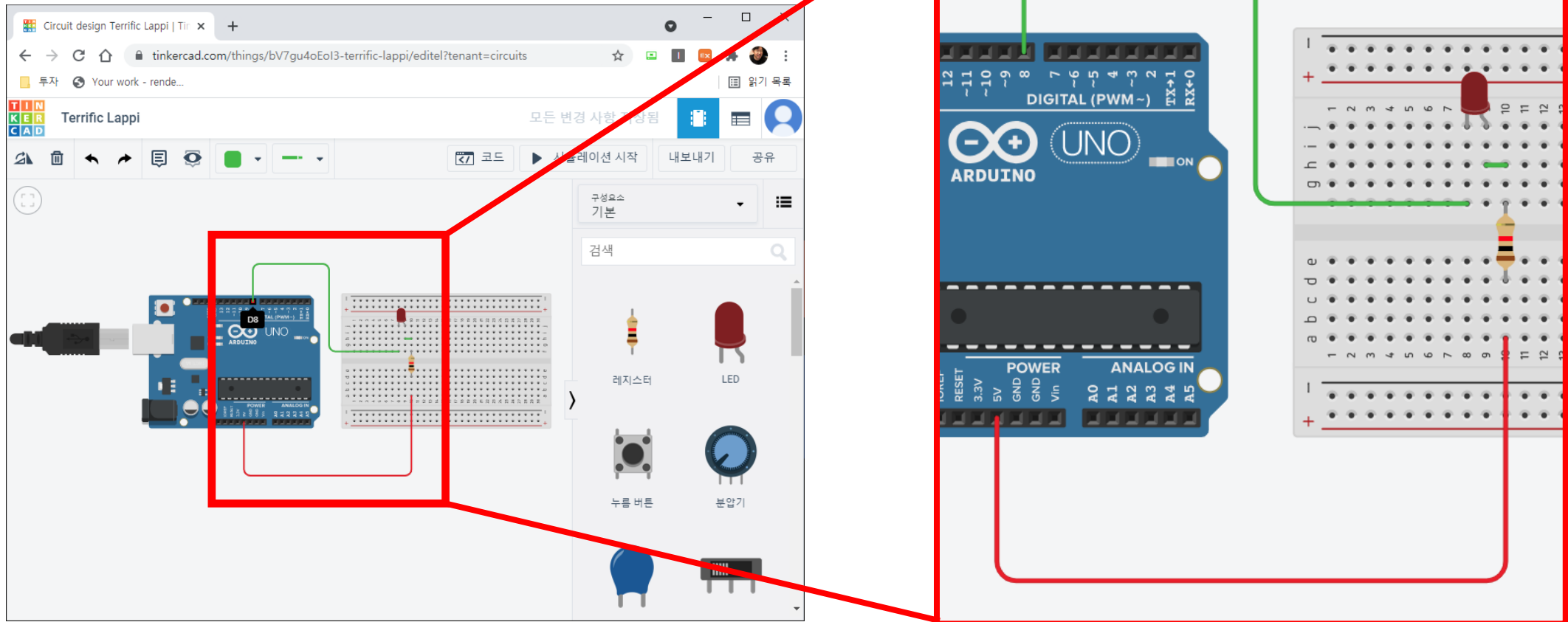
아두이노 개발 환경 구성 및 LED 테스트

- Arduino LED 회로 구성



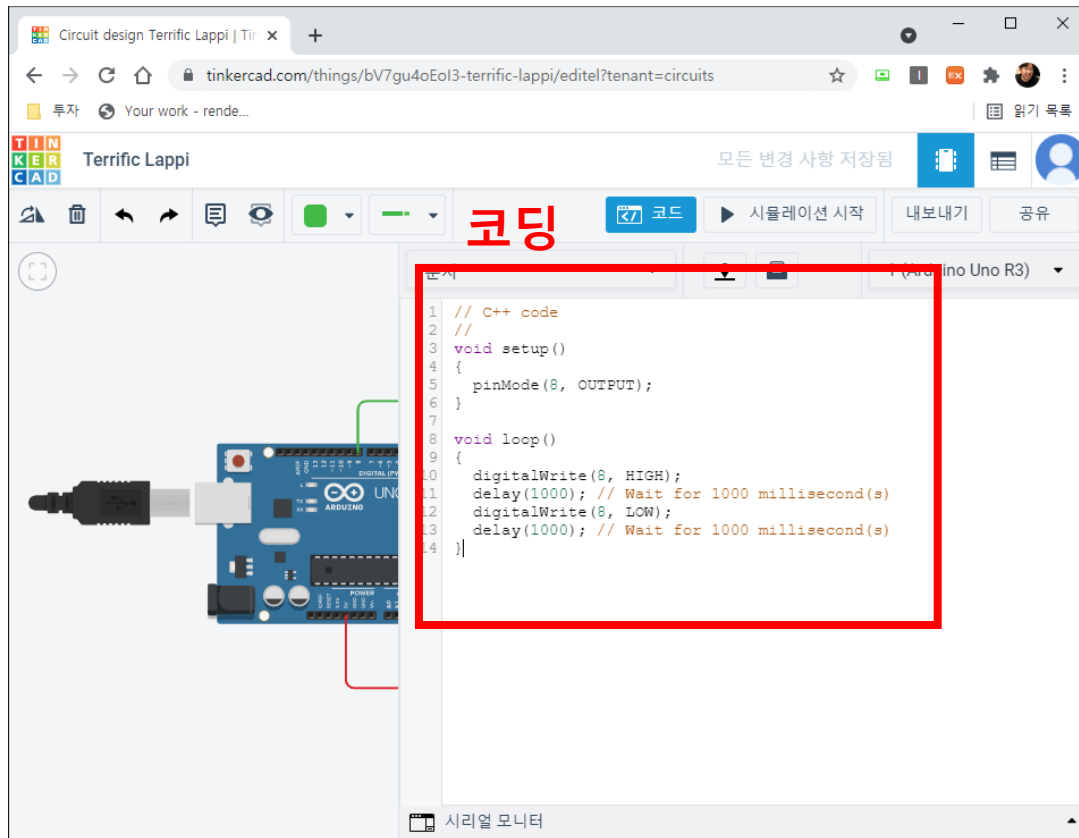
아두이노를 이용한 LED 실험

- tinkercad.com : 전체 회로 구성



아두이노를 이용한 LED 실험

- tinkercad.com : 코드 작성

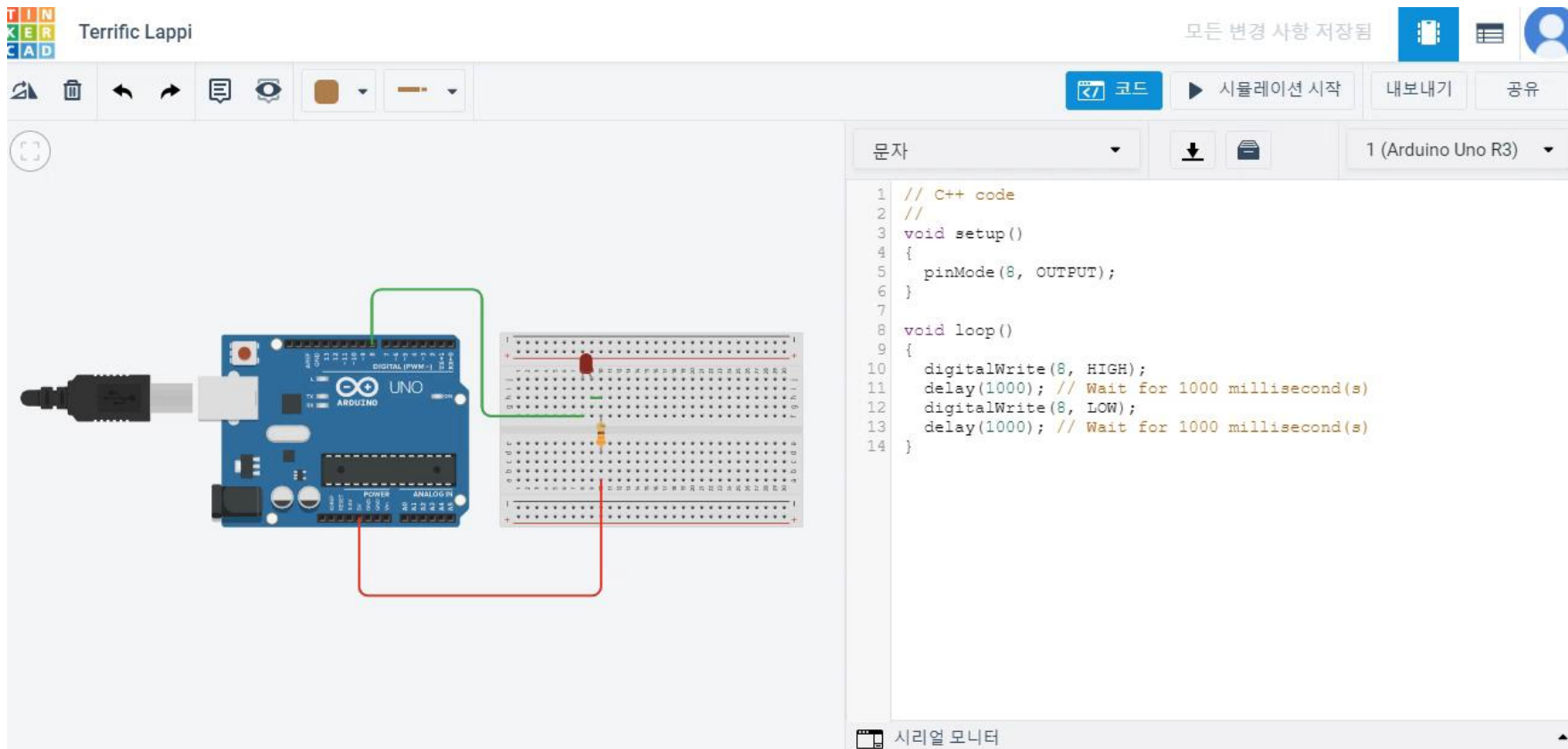


```
// C++ code
//
void setup()
{
    pinMode(8, OUTPUT);
}

void loop()
{
    digitalWrite(8, HIGH);
    delay(1000); // Wait for 1000 millisecond(s)
    digitalWrite(8, LOW);
    delay(1000); // Wait for 1000 millisecond(s)
}
```

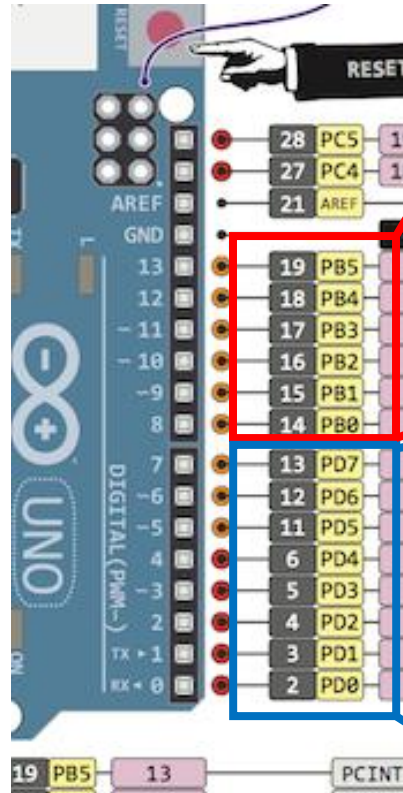
아두이노를 이용한 LED 실험

- tinkercad.com : 시뮬레이션 시작



디지털 IO 포트 관련 레지스터

- Port



13.4.2 PORTB – The Port B Data Register

[illegible]

13.4.3 DDRB – The Port B Data Direction Register

[illegible]

13.4.4 PINB – The Port B Input Pins Address

[illegible]

13.4.8 PORTD – The Port D Data Register

Bit	7	6	5	4	3	2	1	0
0x0B (0x2B)	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Initial Value	0	0	0	0	0	0	0	0

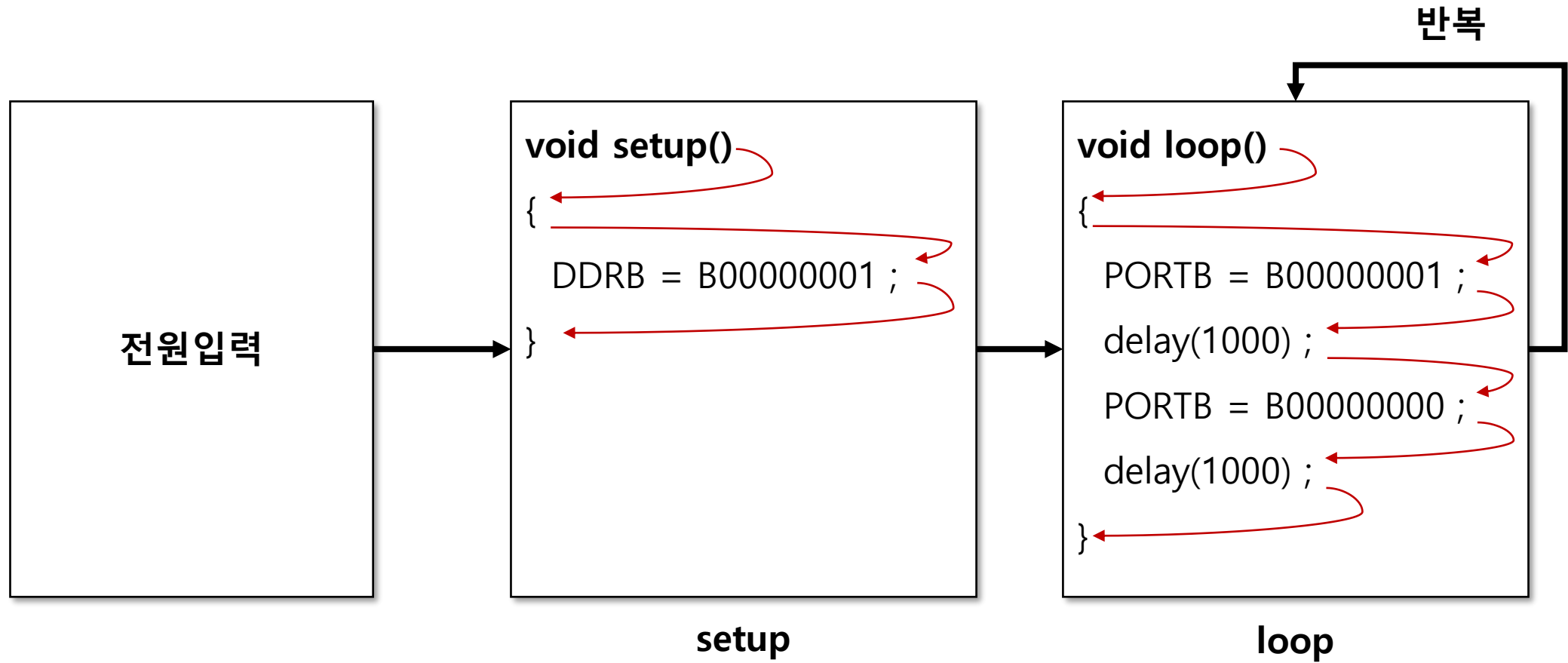
13.4.9 DDRD – The Port D Data Direction Register

[illegible]

13.4.10 PIND – The Port D Input Pins Address

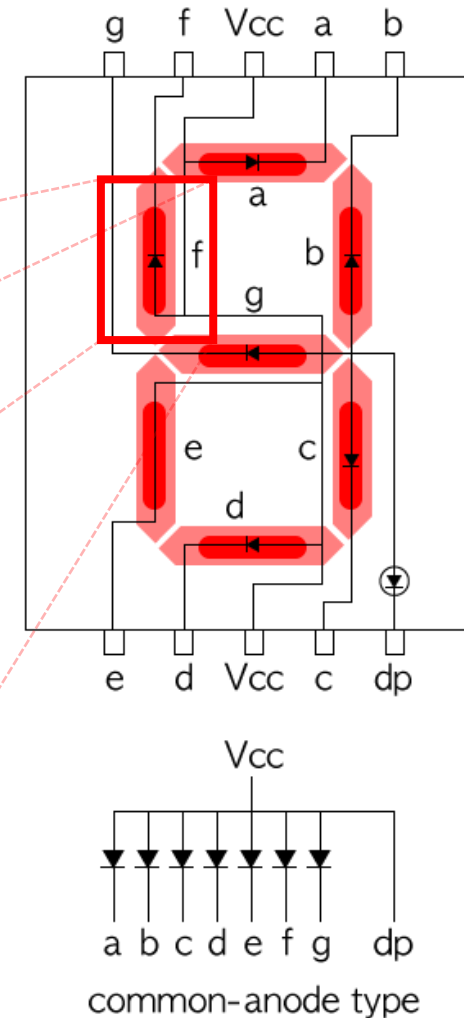
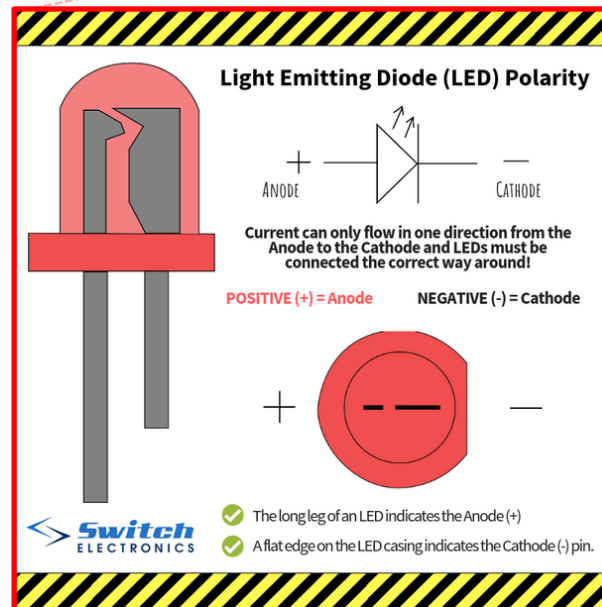
[illegible]

IO 포트 출력 실험



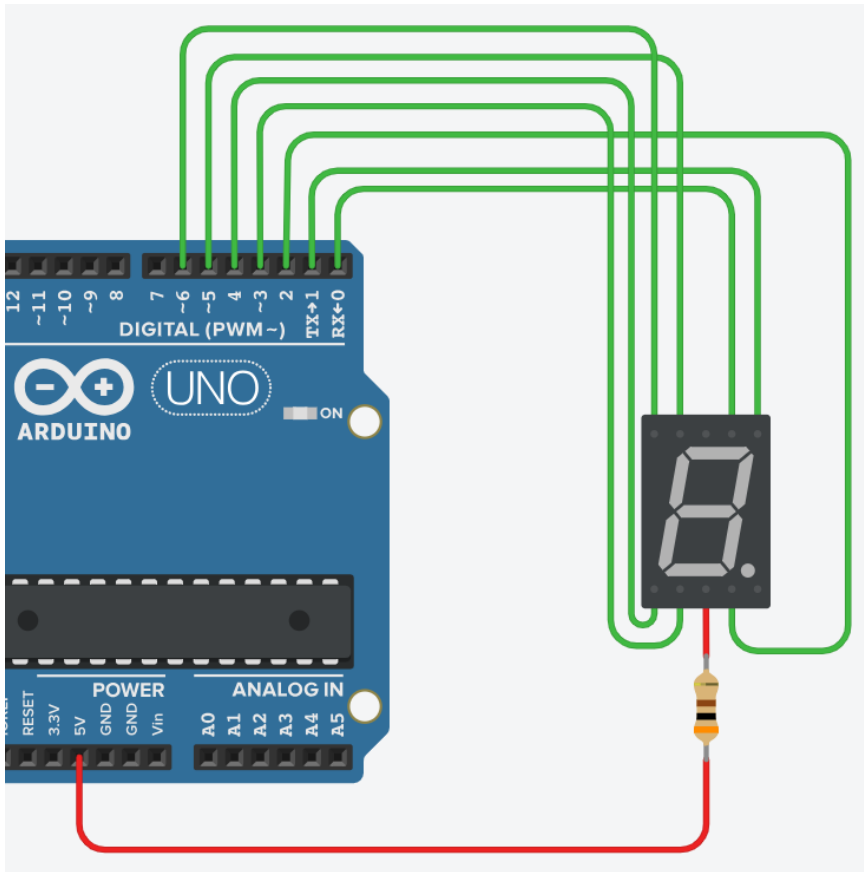
LED를 이용한 포트 제어 실험

- 7-segment 실험



LED를 이용한 포트 제어 실험

- 7-segment 실험



a	→	PD0
b	→	PD1
c	→	PD2
d	→	PD3
e	→	PD4
f	→	PD5
g	→	PD6
DP	→	PD7

LED를 이용한 포트 제어 실험

• 7-segment 실험

0 = a(0) b(0) c(0) d(0) e(0) f(0) g(1) DP(1)

1 = a(1) b(0) c(0) d(1) e(1) f(1) g(1) DP(1)

2 = a(0) b(0) c(1) d(0) e(0) f(1) g(0) DP(1)

3 = a(0) b(0) c(0) d(0) e(1) f(1) g(0) DP(1)

4 = a(1) b(0) c(0) d(1) e(1) f(0) g(0) DP(1)

5 = a(0) b(1) c(0) d(0) e(1) f(0) g(0) DP(1)

6 = a(0) b(1) c(0) d(0) e(0) f(0) g(0) DP(1)

7 = a(0) b(0) c(0) d(1) e(1) f(0) g(1) DP(1)

8 = a(0) b(0) c(0) d(0) e(0) f(0) g(0) DP(1)

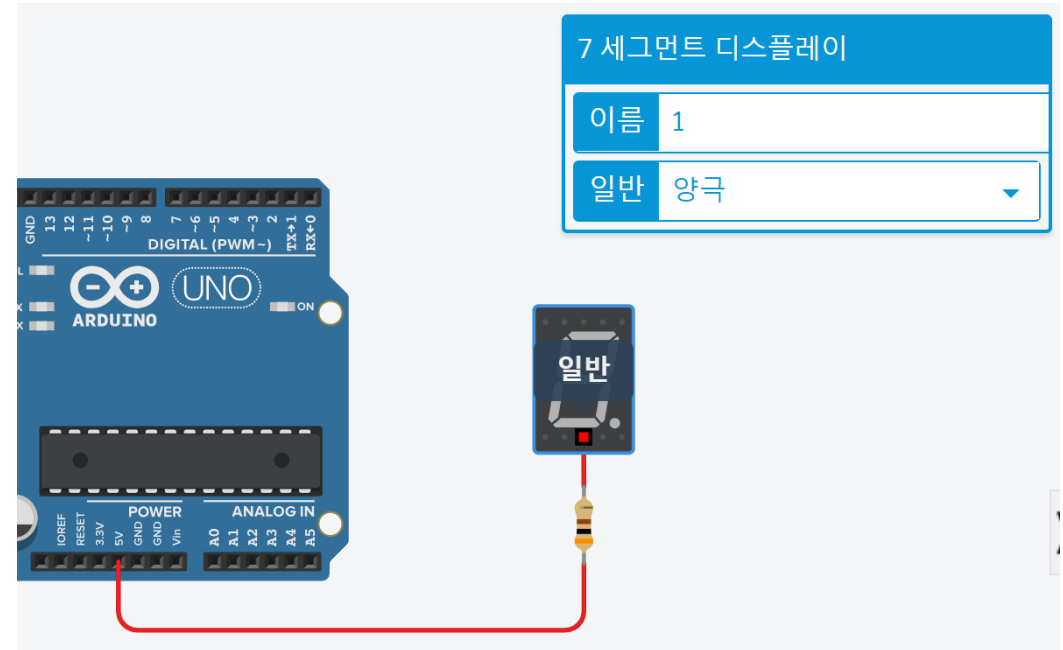
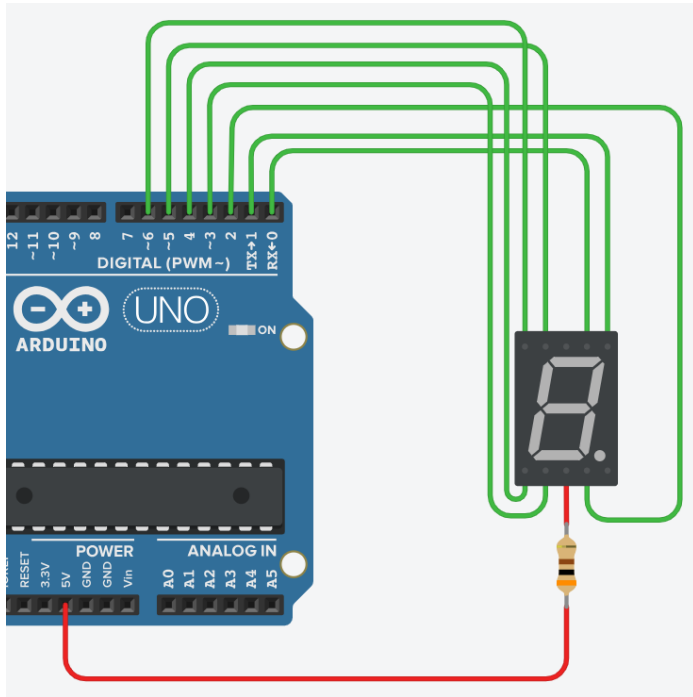
9 = a(0) b(0) c(0) d(0) e(1) f(0) g(0) DP(1)

. = DP(0)

		a	b	c	d	e	f	g	DP
		PD0	PD1	PD2	PD3	PD4	PD5	PD6	PD7
0	→	0	0	0	0	0	0	1	1
1	→	1	0	0	1	1	1	1	1
2	→	0	0	1	0	0	1	0	1
3	→	0	0	0	0	1	1	0	1
4	→	1	0	0	1	1	0	0	1
5	→	0	1	0	0	1	0	0	1
6	→	0	1	0	0	0	0	0	1
7	→	0	0	0	1	1	0	1	1
0	→	0	0	0	0	0	0	0	1
9	→	0	0	0	0	1	0	0	1

LED를 이용한 포트 제어 실험

- 7-segment 실험



LED를 이용한 포트 제어 실험

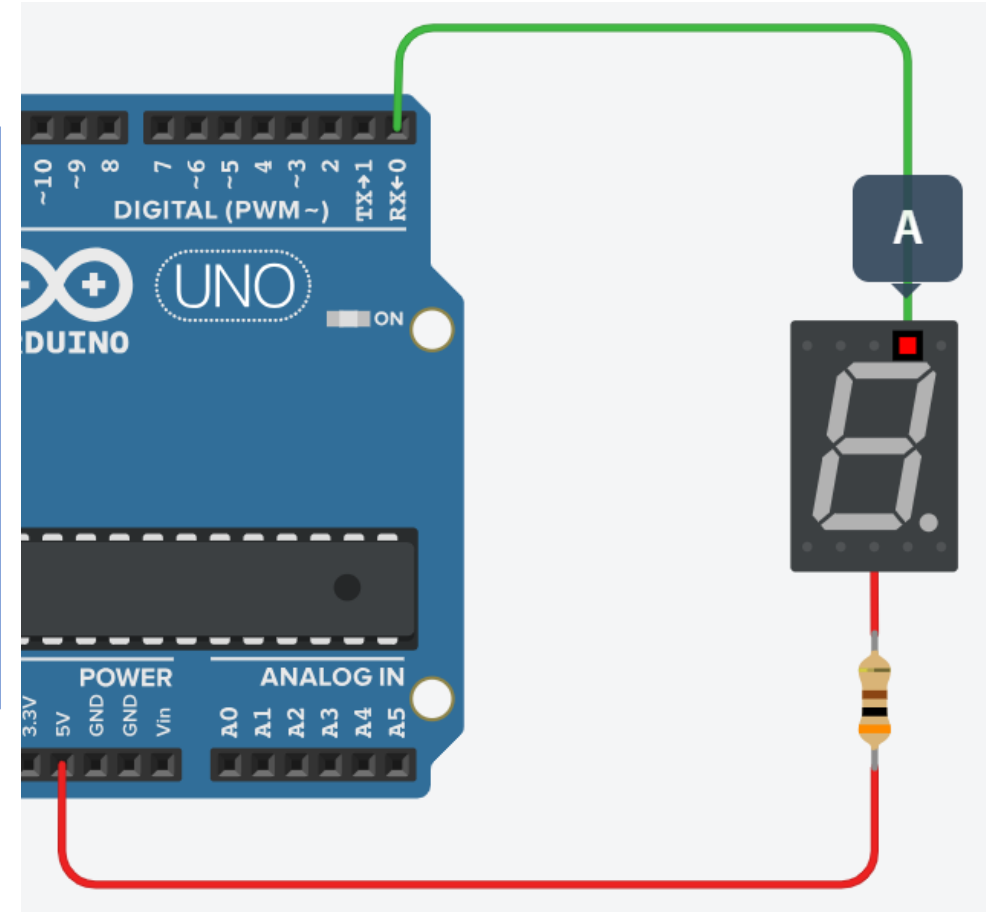
• 7-segment 실험

```
void setup()
{
  DDRD = B00000001 ;
}

void loop()
{
  PORTD = B00000000 ;
}
```

```
void setup()
{
  DDRD = B00000001 ;
}

void loop()
{
  PORTD = B00000001 ;
}
```



LED를 이용한 포트 제어 실험

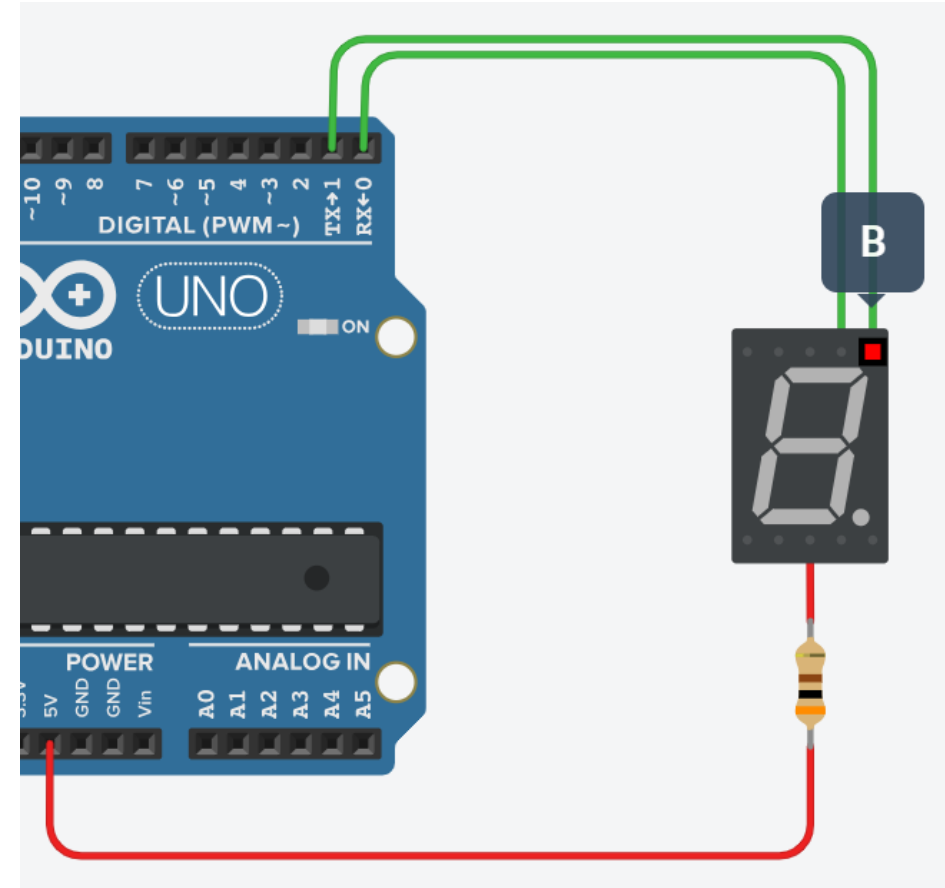
• 7-segment 실험

```
void setup()
{
  DDRD = B00000011 ;
}

void loop()
{
  PORTD = B00000000 ;
}
```

```
void setup()
{
  DDRD = B00000011 ;
}

void loop()
{
  PORTD = B00000011 ;
}
```



LED를 이용한 포트 제어 실험

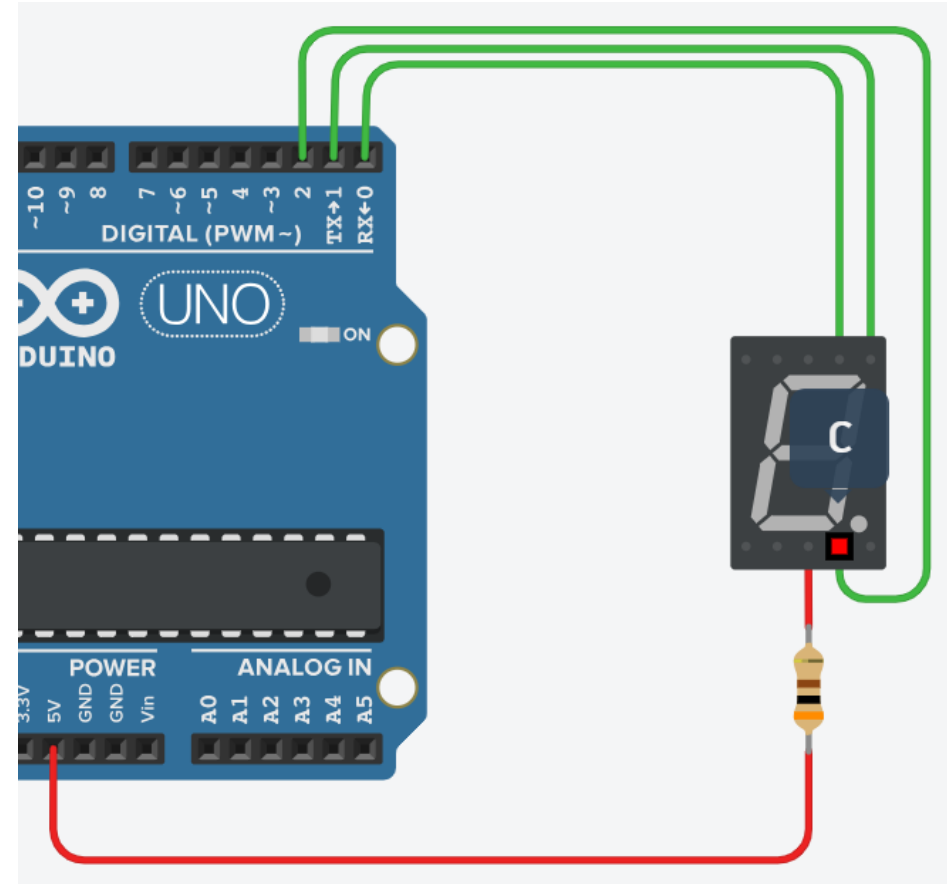
• 7-segment 실험

```
void setup()
{
  DDRD = B00000111;
}

void loop()
{
  PORTD = B00000000;
}
```

```
void setup()
{
  DDRD = B00000111;
}

void loop()
{
  PORTD = B00000111;
}
```



LED를 이용한 포트 제어 실험

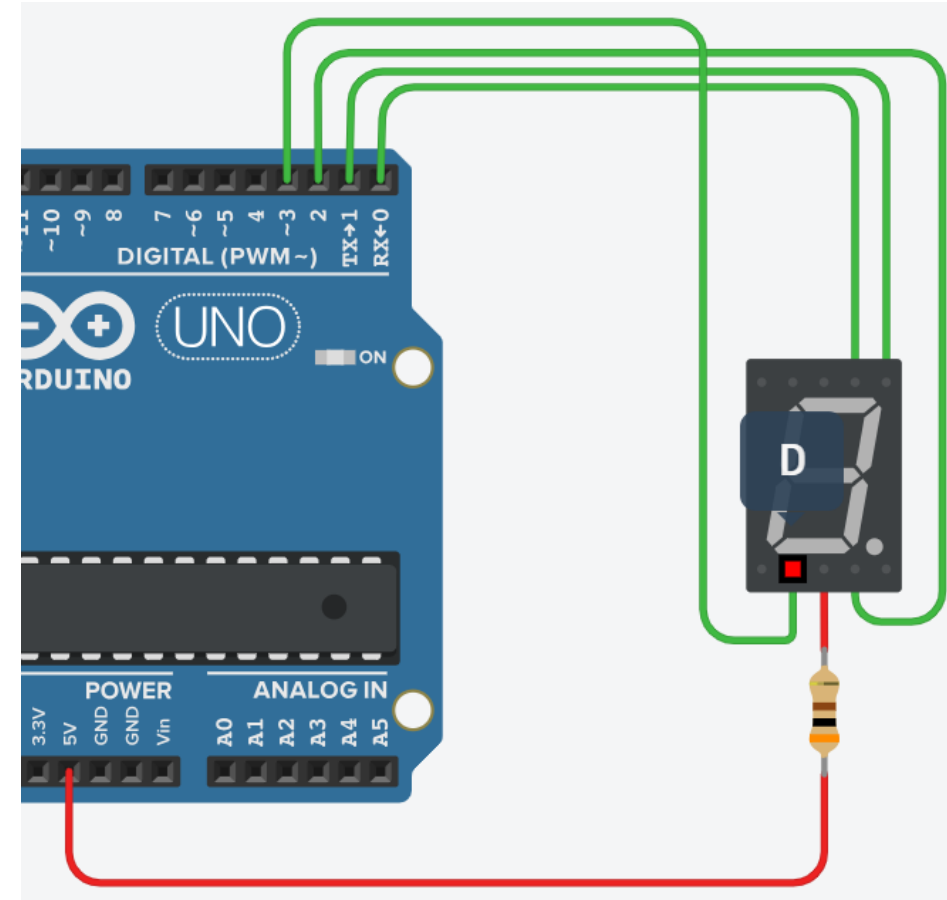
- 7-segment 실험

```
void setup()
{
  DDRD = B00001111 ;
}

void loop()
{
  PORTD = B00000000 ;
}
```

```
void setup()
{
  DDRD = B00001111 ;
}

void loop()
{
  PORTD = B00001111 ;
}
```



LED를 이용한 포트 제어 실험

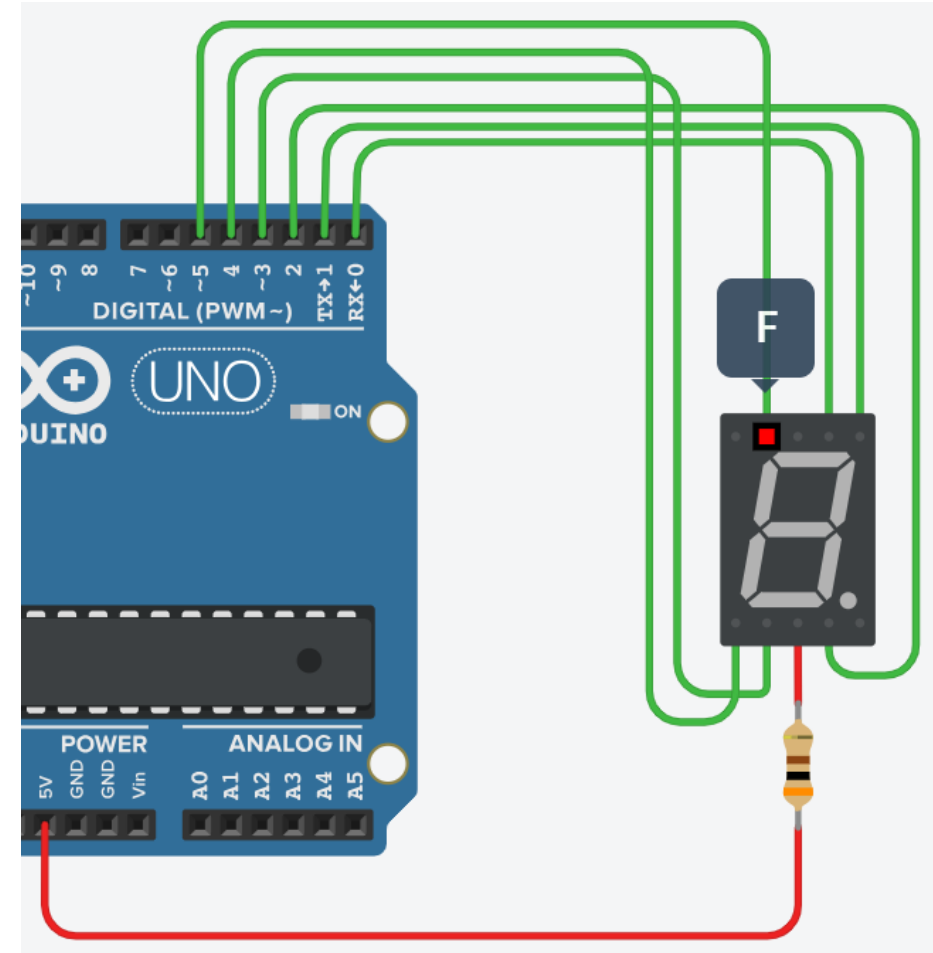
- 7-segment 실험

```
void setup()
{
  DDRD = B00111111;
}

void loop()
{
  PORTD = B0000000;
}
```

```
void setup()
{
  DDRD = B00111111;
}

void loop()
{
  PORTD = B00111111;
}
```



LED를 이용한 포트 제어 실험

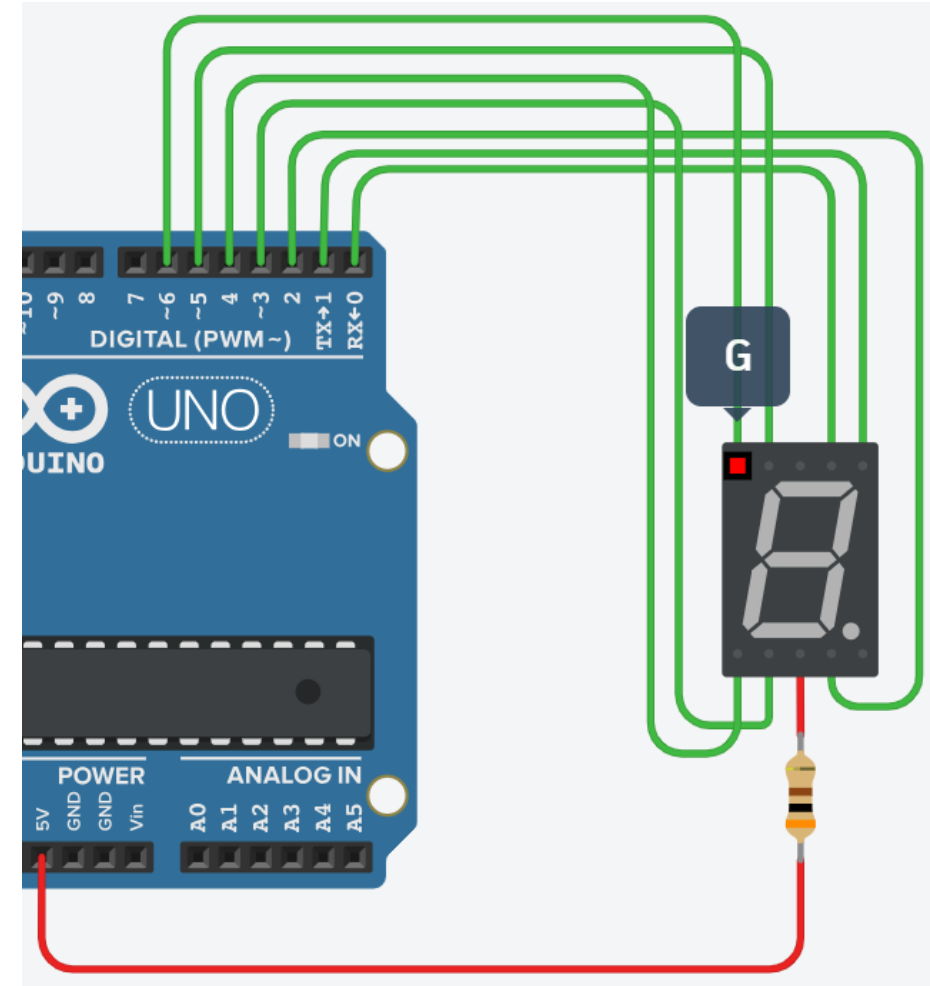
• 7-segment 실험

```
void setup()
{
  DDRD = B01111111;
}

void loop()
{
  PORTD = B00000000;
}
```

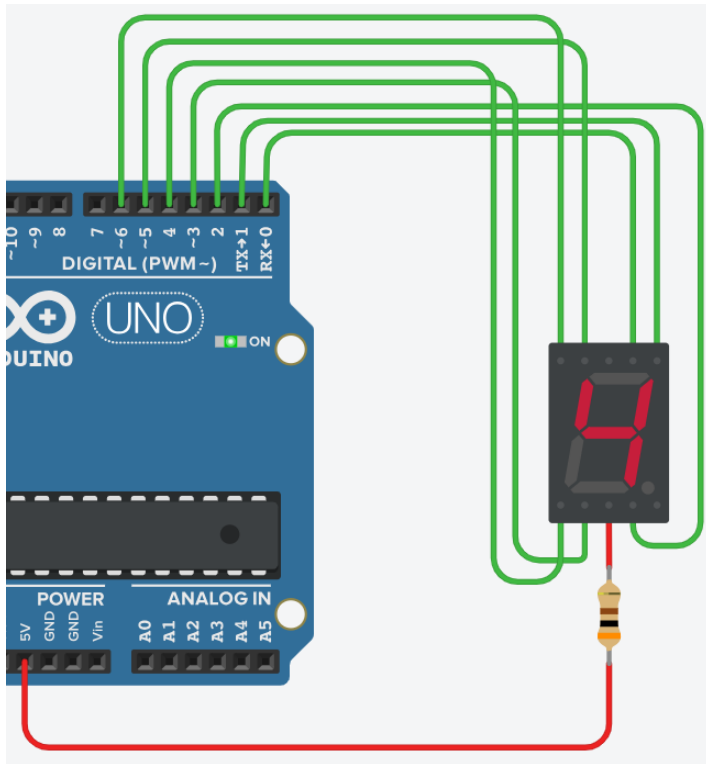
```
void setup()
{
  DDRD = B01111111;
}

void loop()
{
  PORTD = B01111111;
}
```



LED를 이용한 포트 제어 실험

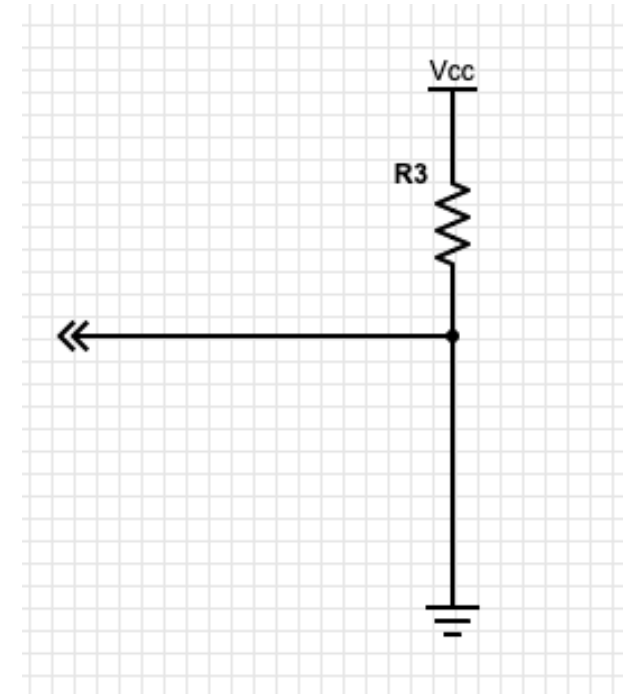
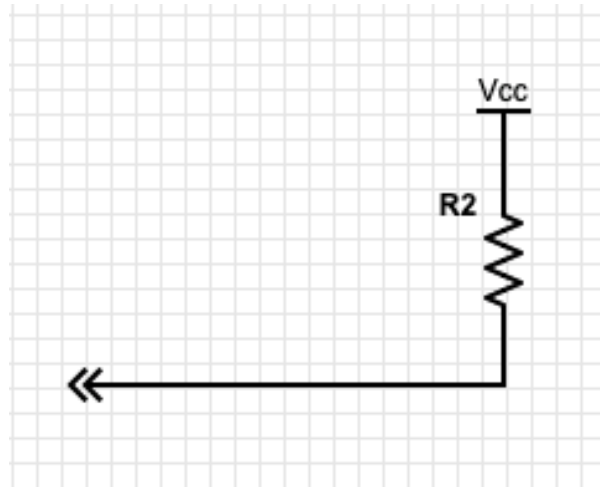
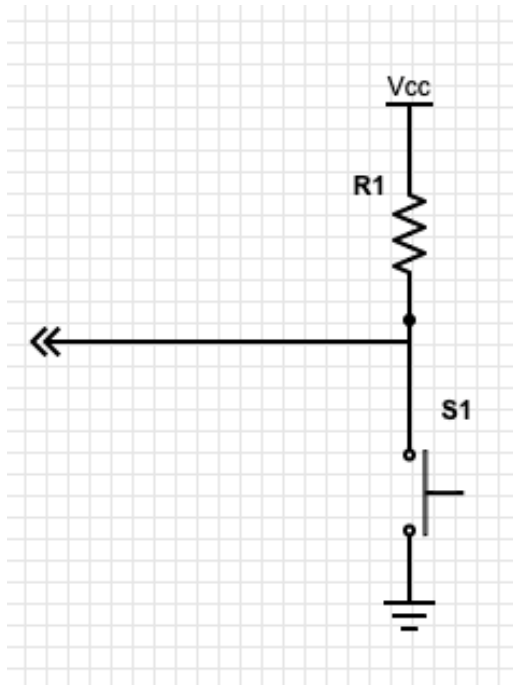
- 7-segment 실험 QUIZ – 숫자 **4**와 **2**를 1초 간격으로 표시 하는 코드를 완성 하시오.



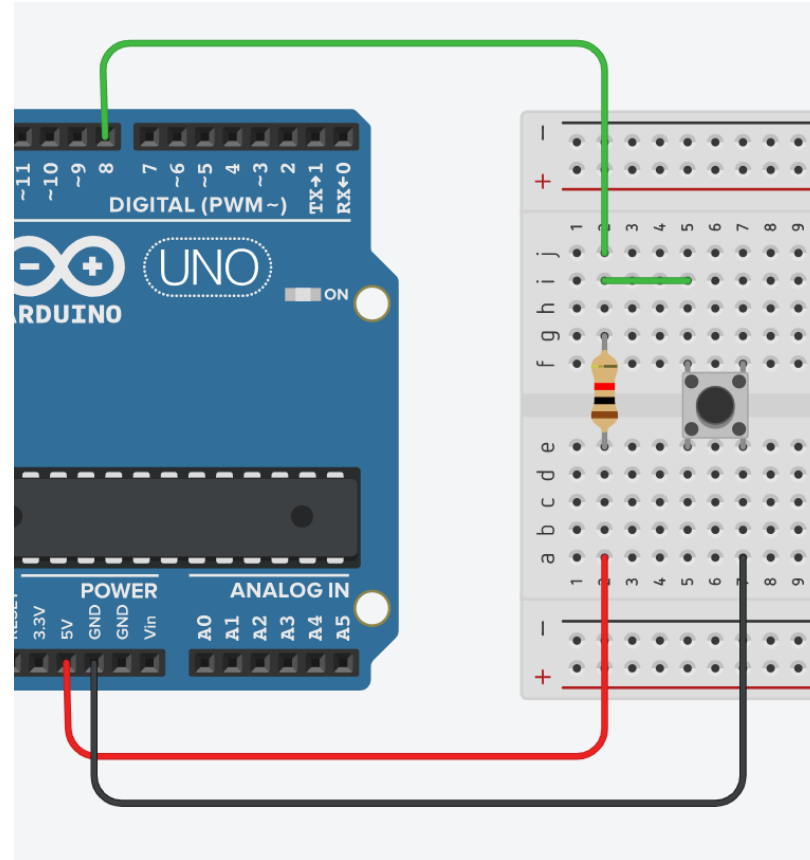
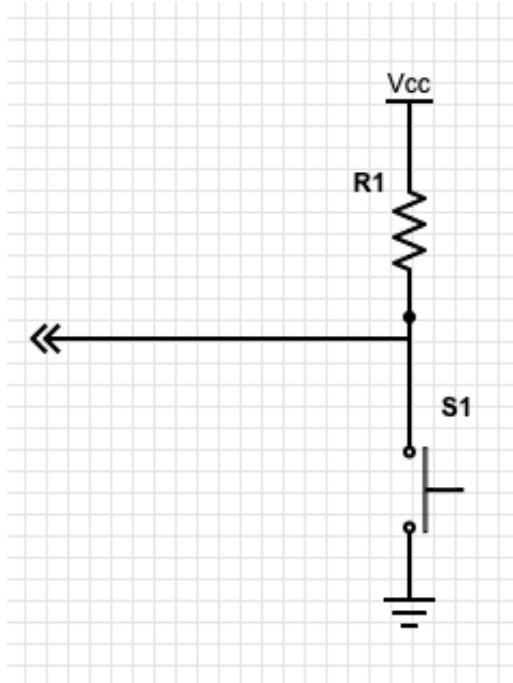
```
void setup()
{
    DDRD = B[_____];
}

void loop()
{
    PORTD = B[_____];
    delay(1000);
    PORTD = B[_____];
    delay(1000);
}
```

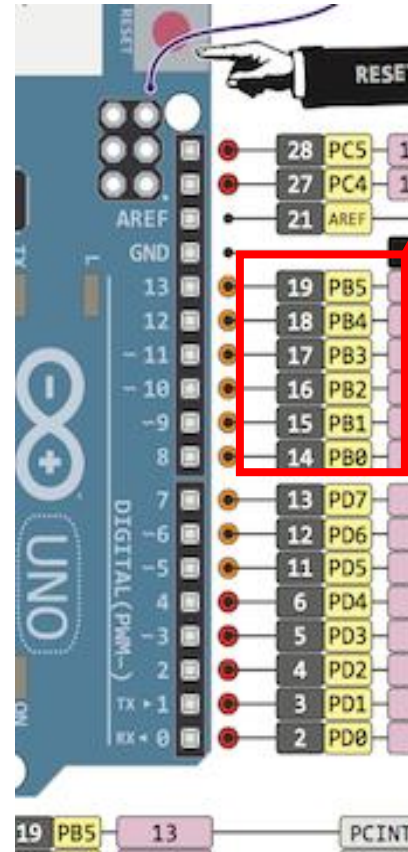
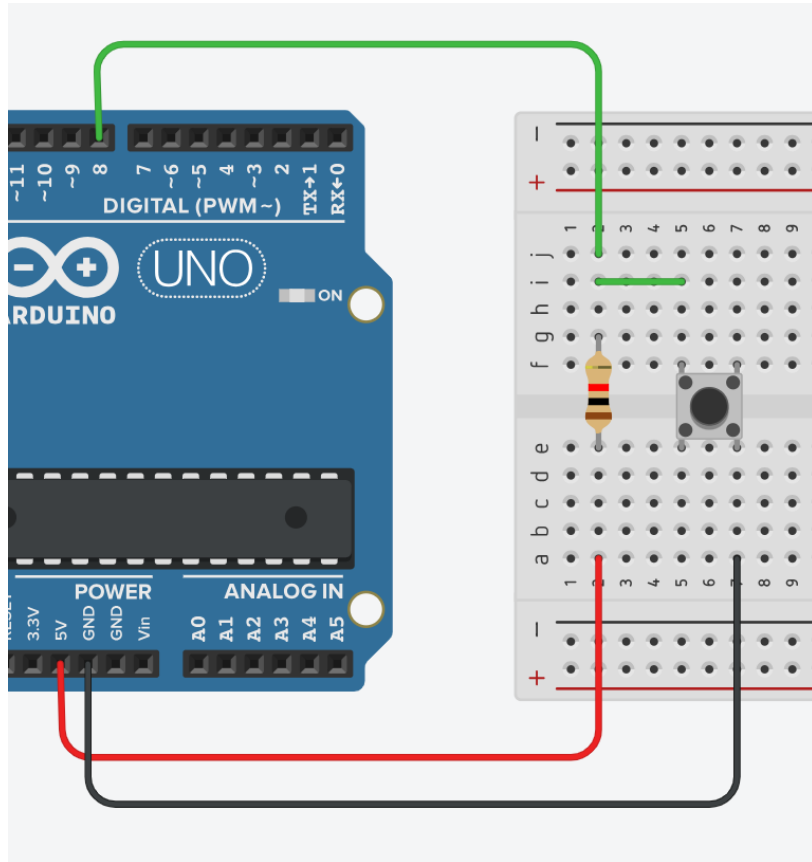
버튼 입력 실험(Digital Input)



버튼 입력 실험(Digital Input)



버튼 입력 실험(Digital Input)



13.4.2 PORTB – The Port B Data Register

Bit	7	6	5	4	3	2	1	0
0x05 (0x25)	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Initial Value	0	0	0	0	0	0	0	0

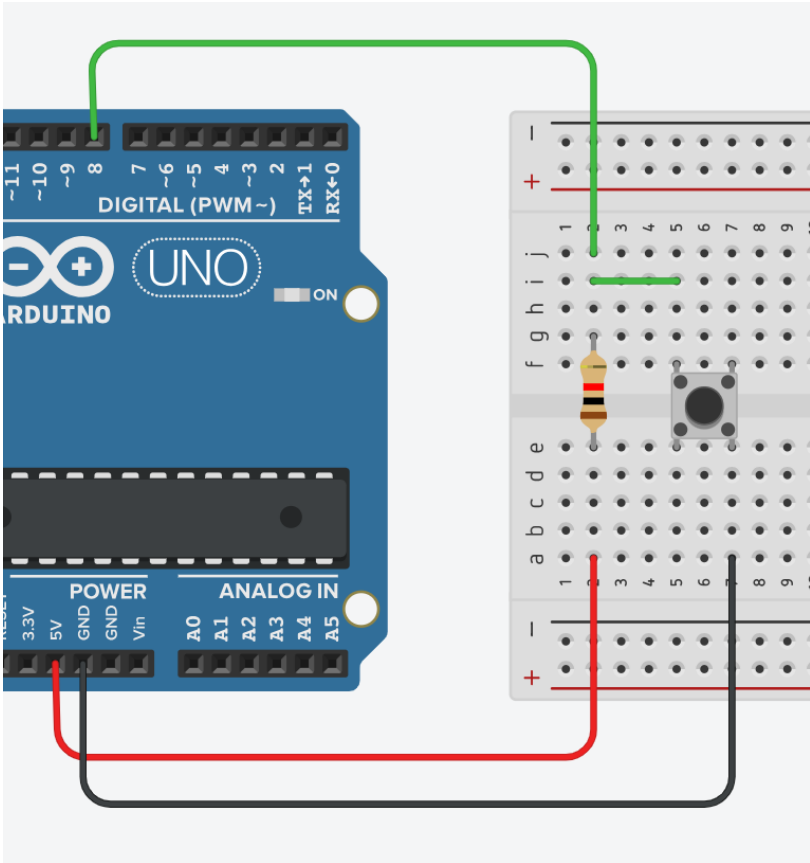
13.4.3 DDRB – The Port B Data Direction Register

Bit	7	6	5	4	3	2	1	0
0x04 (0x24)	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Initial Value	0	0	0	0	0	0	0	0

13.4.4 PINB – The Port B Input Pins Address

[illegible]

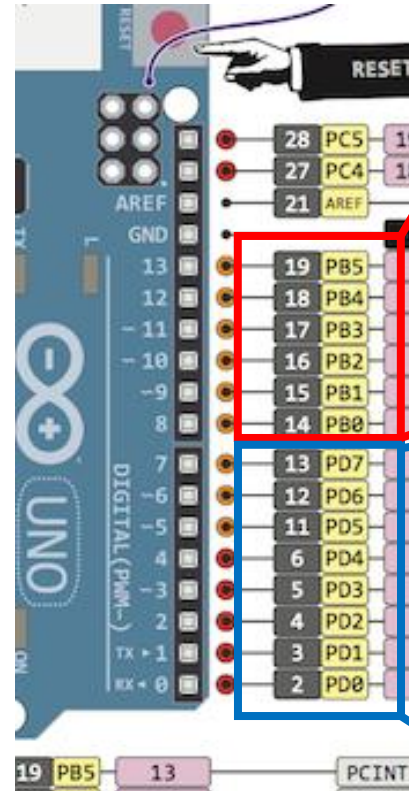
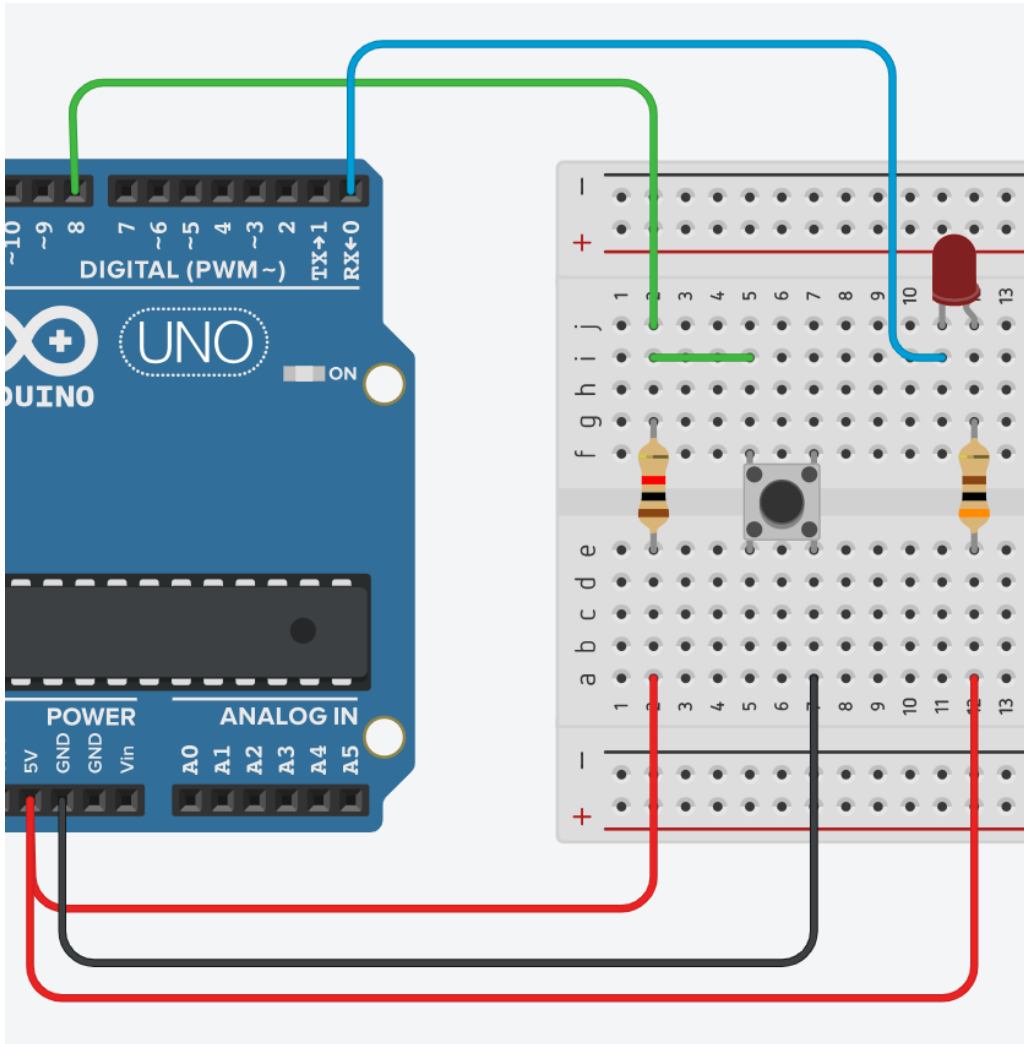
버튼 입력 실험(Digital Input)



```
void setup()
{
  DDRB = B00000000;
  Serial.begin(9600);
}

void loop()
{
  Serial.println(PINB);
}
```

디지털 입출력 실험



13.4.2 PORTB – The Port B Data Register

[illegible]

13.4.3 DDRB – The Port B Data Direction Register

Bit	7	6	5	4	3	2	1	0
0x04 (0x24)	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Initial Value	0	0	0	0	0	0	0	0

DDBR8

13.4.4 PINB – The Port B Input Pins Address

[illegible]

13.4.8 PORTD – The Port D Data Register

[illegible]

13.4.9 DDRD – The Port D Data Direction Register

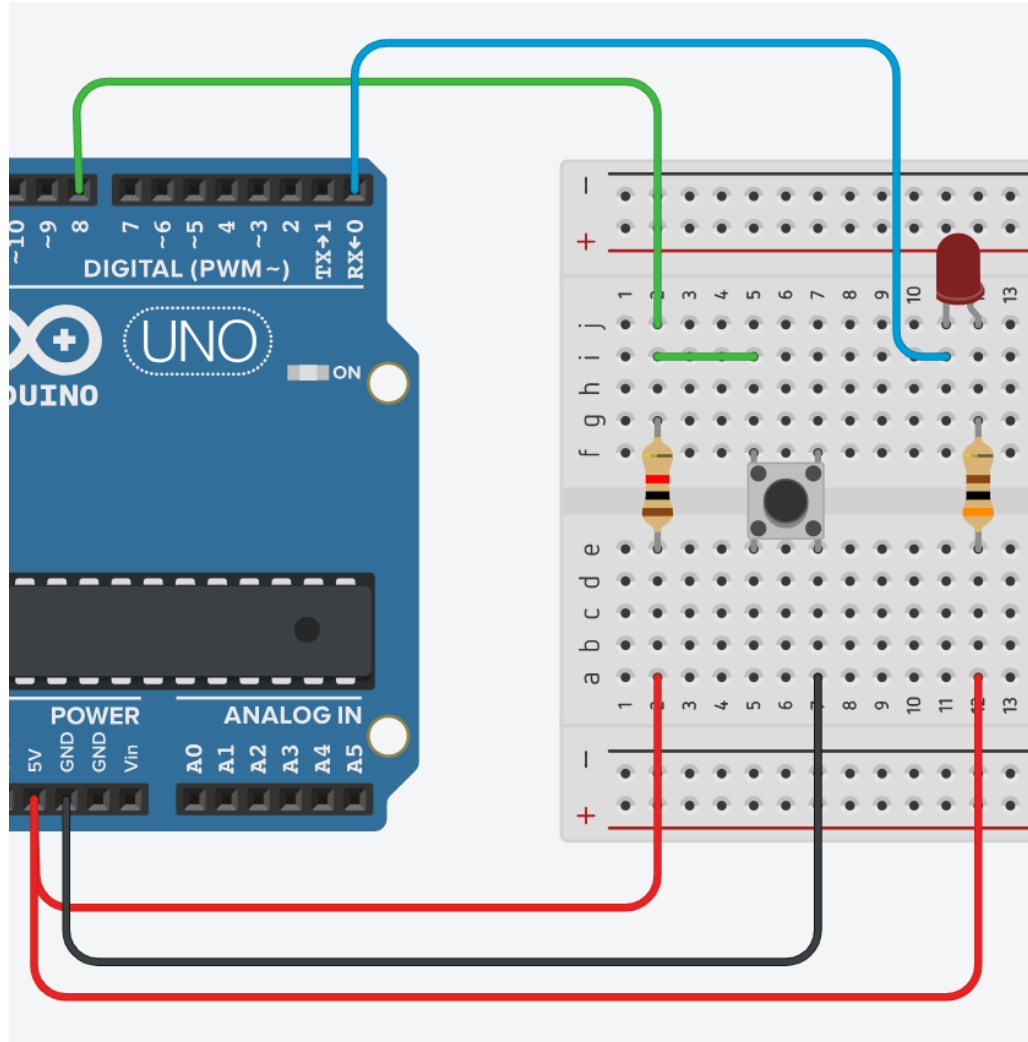
Bit	7	6	5	4	3	2	1	0
0x0A (0x2A)	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Initial Value	0	0	0	0	0	0	0	0

DDRD

13.4.10 PIND – The Port D Input Pins Address

[illegible]

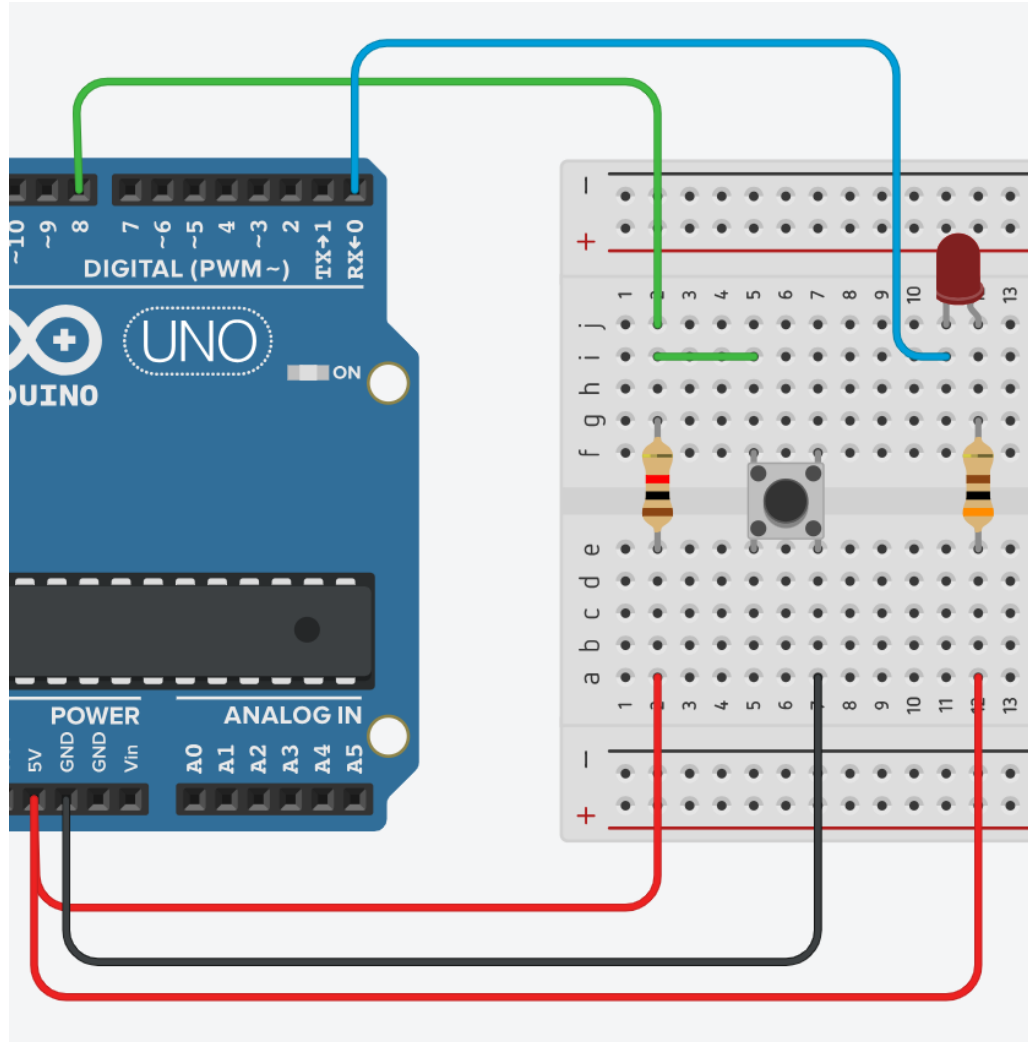
디지털 입출력 실험



```
void setup()
{
  DDRB = B000000000;
  DDRD = B000000001;
}

void loop()
{
  PORTD = PINB ;
}
```

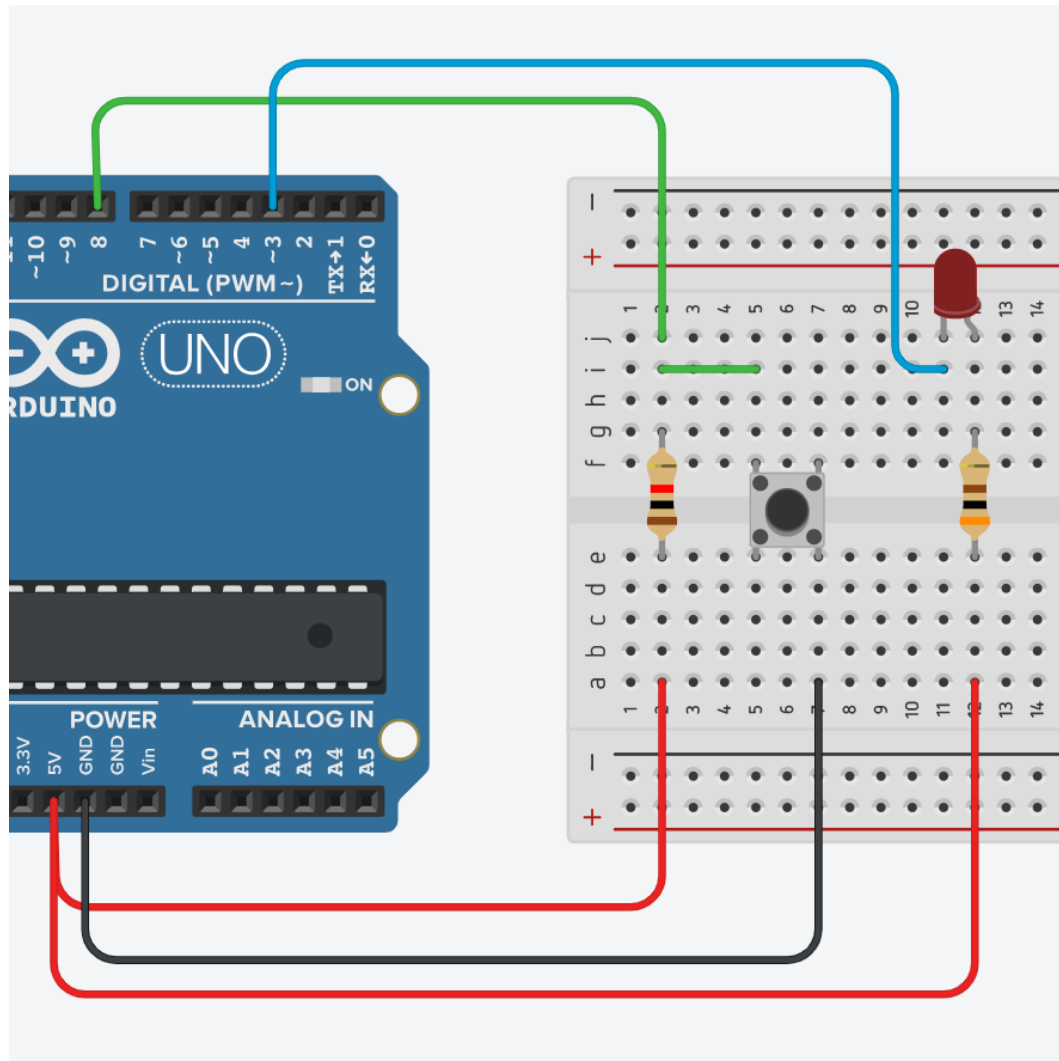
디지털 입출력 실험



```
void setup()
{
  DDRB = B000000000;
  DDRD = B000000001;
}

void loop()
{
  int input = PINB;
  PORTD = input;
}
```

디지털 입출력 실험



```
void setup()
{
  DDRB = B000000000;
  DDRD = B00010000;
}

void loop()
{
  int input = PINB;
  PORTD = input;
}
```

출력 포트가 3번핀(PortD.3)으로 변경되었다면?

디지털 입출력 관련 API

- pinMode
- digitalRead
- digitalWrite

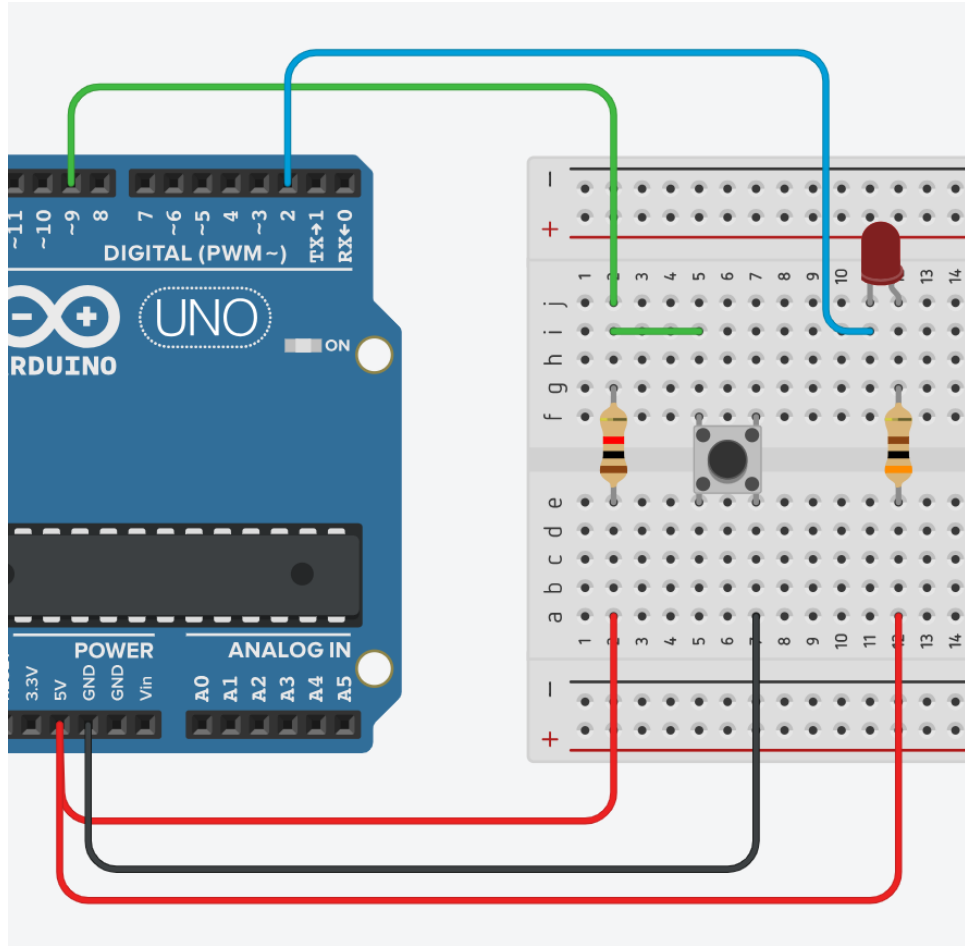
디지털 입출력 관련 API

- 디지털 입출력핀의 방향을 설정

pinMode(핀번호, 방향) ;

- **pinMode(8, INPUT) ;**
- **pinMode(8, OUTPUT) ;**

디지털 입출력 API 실험



9번핀(PortB.1)을 입력핀으로
2번핀(PortD.2)을 출력핀으로
버튼이 눌렸을 때만 LED의 불이 들어 오도록 코드를 완성하시오.

```
void setup()
{
    pinMode(9, INPUT) ;
    pinMode(2, OUTPUT) ;
}

void loop()
{
}
```

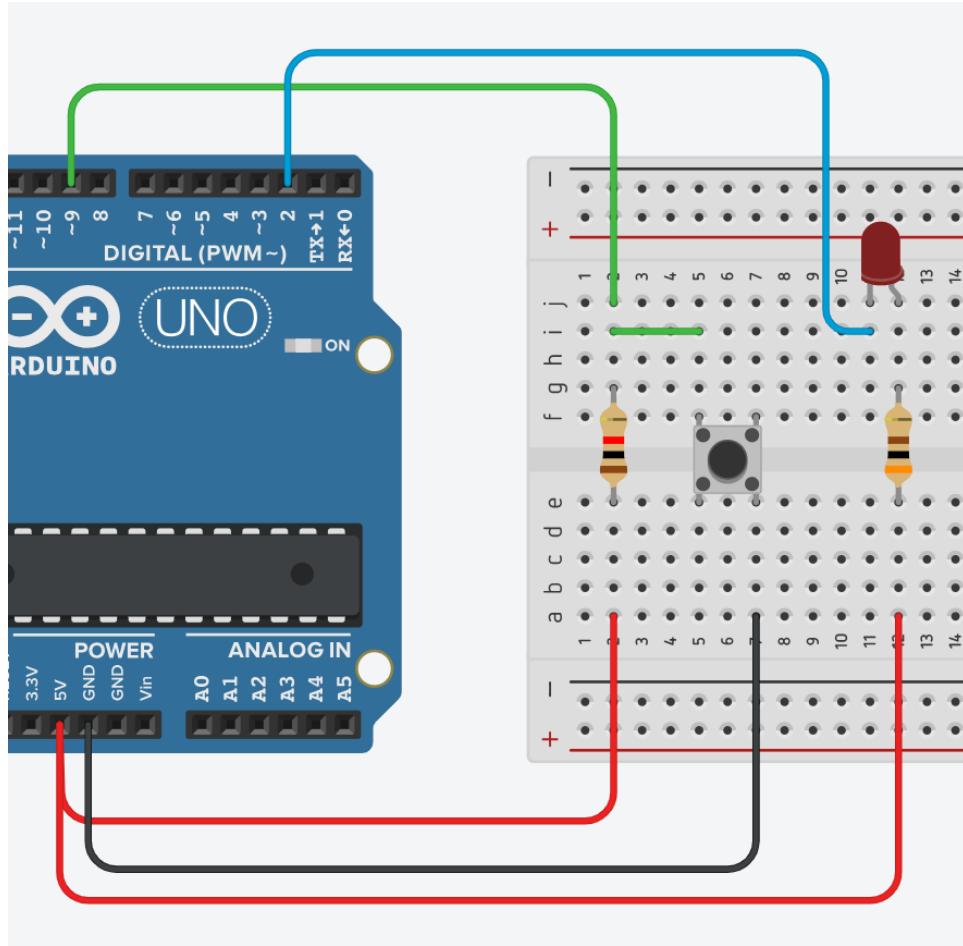

디지털 입출력 관련 API

- 디지털 입력

digitalRead(핀번호) ;

- **int input = digitalRead(8) ;**

디지털 입출력 API 실험



9번핀(PortB.1)을 입력핀으로
2번핀(PortD.2)을 출력핀으로
버튼이 눌렸을 때만 LED의 불이 들어 오도록 코드를 완성하시오.

```
void setup()
{
    pinMode(9, INPUT) ;
    pinMode(2, OUTPUT) ;
}

void loop()
{
    int input = digitalRead(9) ;
}
```

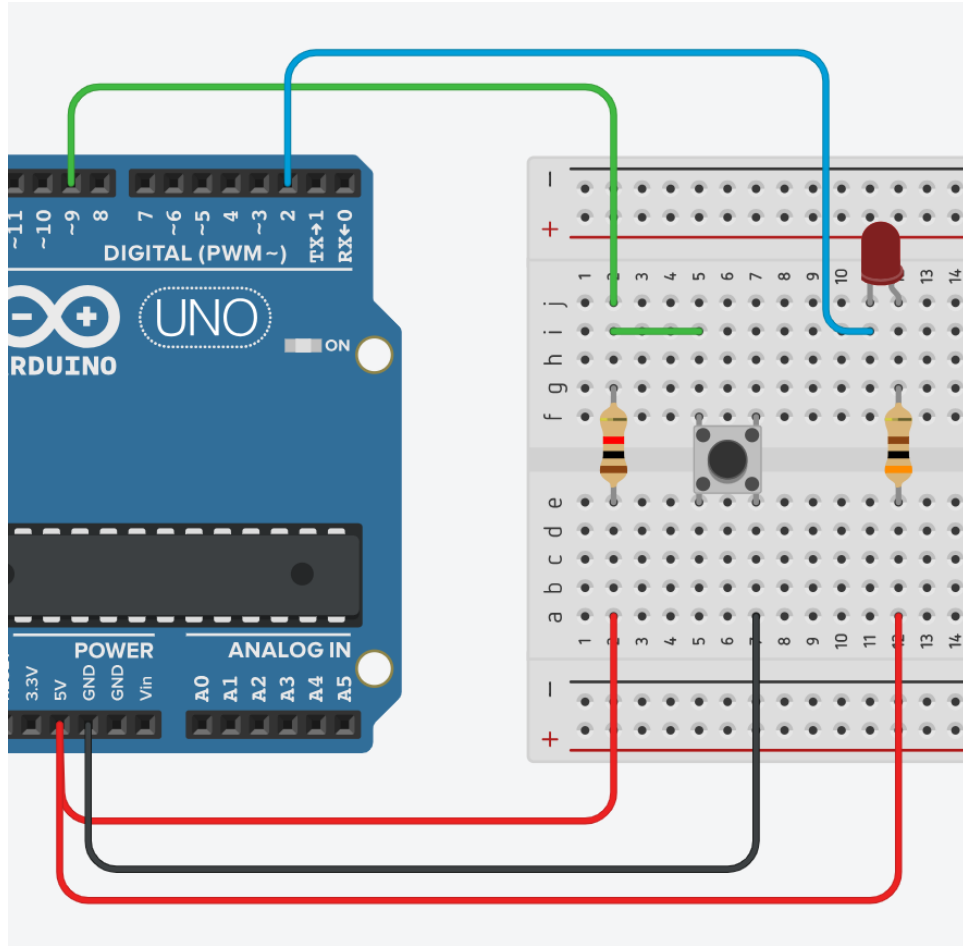
디지털 입출력 관련 API

- 디지털 출력

digitalWrite(핀번호, 출력레벨) ;

- digitalWrite(8, 0) ;
- digitalWrite(8, 1) ;
- digitalWrite(8, LOW) ;
- digitalWrite(8, HIGH) ;

디지털 입출력 API 실험



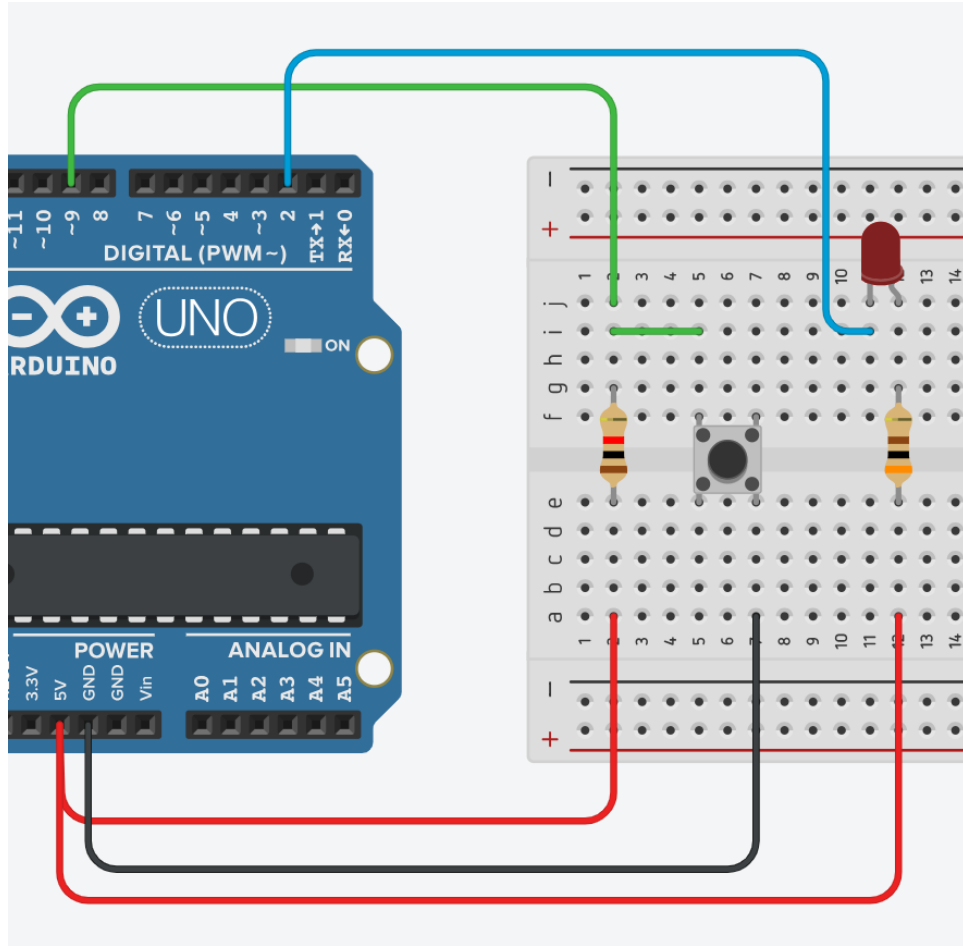
9번핀(PortB.1)을 입력핀으로
2번핀(PortD.2)을 출력핀으로
버튼이 눌렸을 때만 LED의 불이 들어 오도록 코드를 완성하시오.

```
void setup()
{
    pinMode(9, INPUT) ;
    pinMode(2, OUTPUT) ;
}

void loop()
{
    int input = digitalRead(9) ;

    digitalWrite(2, LOW) ;
}
```

디지털 입출력 API 실험



9번핀(PortB.1)을 입력핀으로
2번핀(PortD.2)을 출력핀으로
버튼이 눌렸을 때만 LED의 불이 들어 오도록 코드를 완성하시오.

```
void setup()
{
    pinMode(9, INPUT);
    pinMode(2, OUTPUT);
}

void loop()
{
    int input = digitalRead(9);

    if( input == 0 )
    {
        digitalWrite(2, LOW);
    }
    else
    {
        digitalWrite(2, HIGH);
    }
}
```

부저 실험

• 부저(소리) 출력 실험

- 능동부저:전원을공급하면단음(빠)소리가출력
- 수동부저:진동을만들어특정주파수의소리를출력(다양한소리를출력할수있음,멜로디)

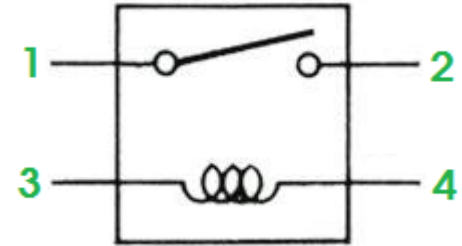


(단위 : Hz)

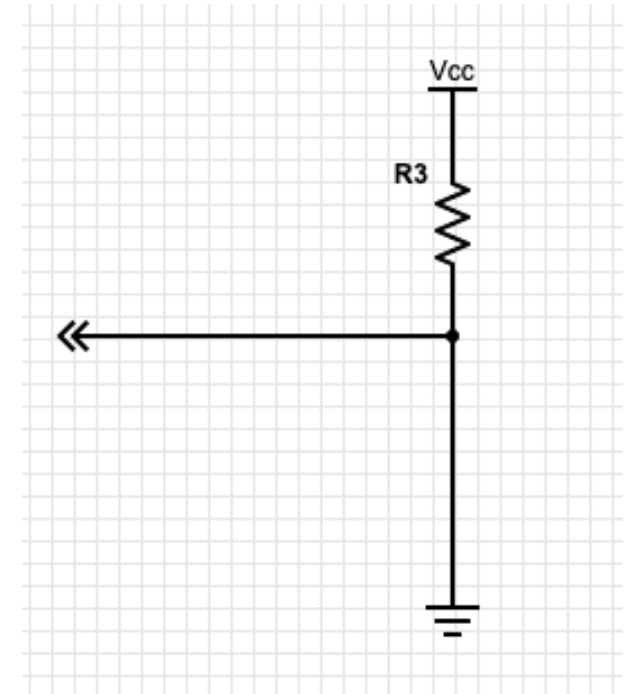
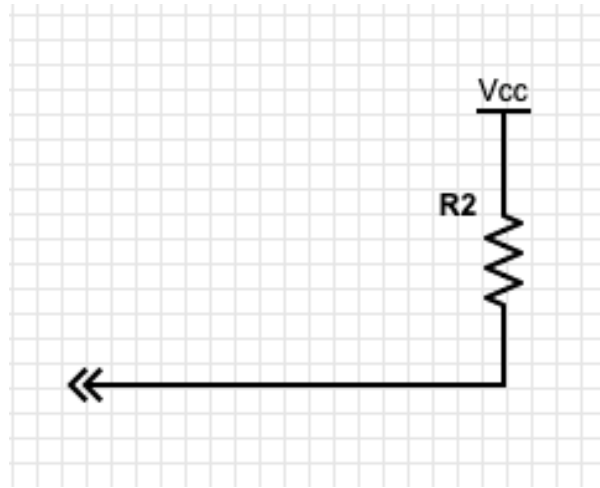
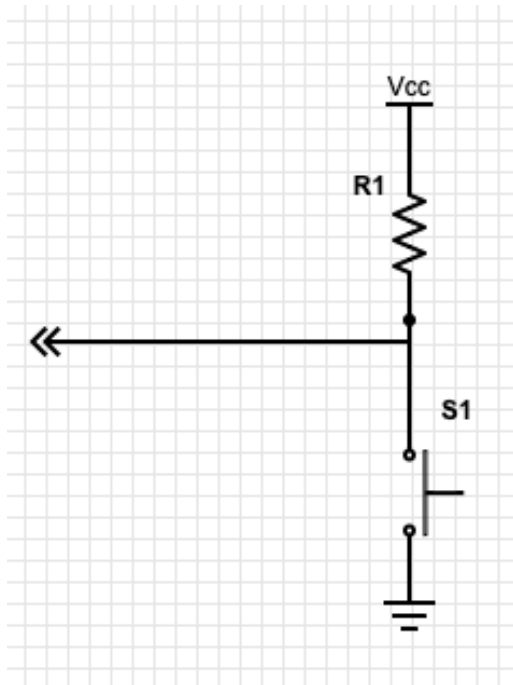
음계 \ 옥타브	1	2	3	4	5	6	7	8
C(도)	32.7032	65.4064	130.8128	261.6256	523.2511	1046.502	2093.005	4186.009
C#	34.6478	69.2957	138.5913	277.1826	554.3653	1108.731	2217.461	4434.922
D(레)	36.7081	73.4162	146.8324	293.6648	587.3295	1174.659	2349.318	4698.636
D#	38.8909	77.7817	155.5635	311.1270	622.2540	1244.508	2489.016	4978.032
E(미)	41.2034	82.4069	164.8138	329.6276	659.2551	1318.510	2637.020	5274.041
F(파)	43.6535	87.3071	174.6141	349.2282	698.4565	1396.913	2793.826	5587.652
F#	46.2493	92.4986	184.9972	369.9944	739.9888	1479.978	2959.955	5919.911
G(솔)	48.9994	97.9989	195.9977	391.9954	783.9909	1567.982	3135.963	6271.927
G#	51.9130	103.8262	207.6523	415.3047	830.6094	1661.219	3322.438	6644.875
A(라)	55.0000	110.0000	220.0000	440.0000	880.0000	1760.000	3520.000	7040.000
A#	58.2705	116.5409	233.0819	466.1638	932.3275	1864.655	3729.310	7458.620
B(시)	61.7354	123.4708	246.9417	493.8833	987.7666	1975.533	3951.066	7902.133

- 도:261.6256Hz
- 레:293.1826Hz
- 미:329.6276 Hz
- 파:349.2282 Hz
- 솔:391.9954 Hz
- 라:440.0000 Hz
- 시:466.1638 Hz
- 도:523.2511 Hz

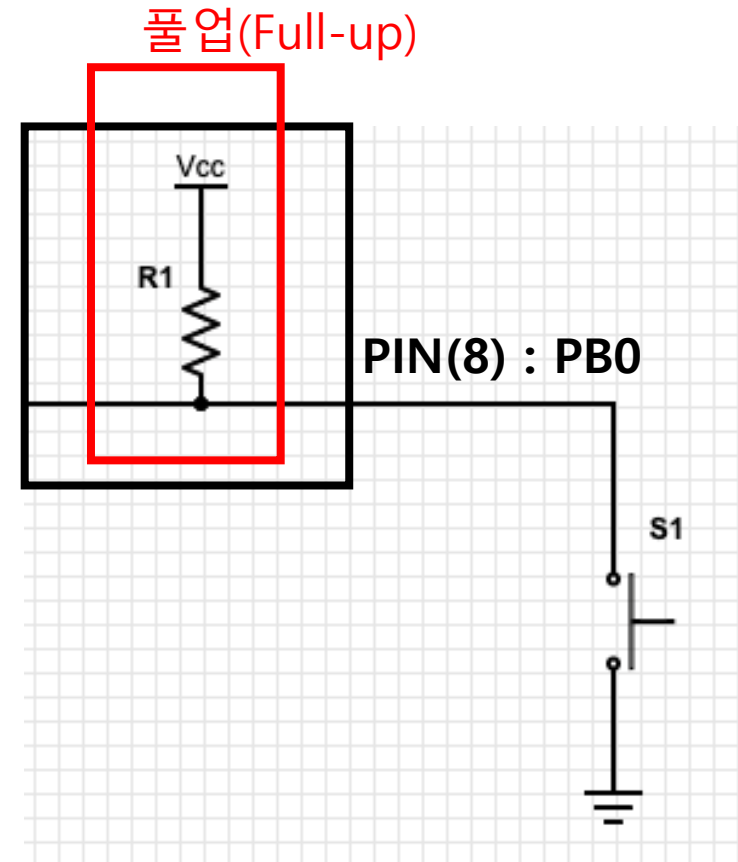
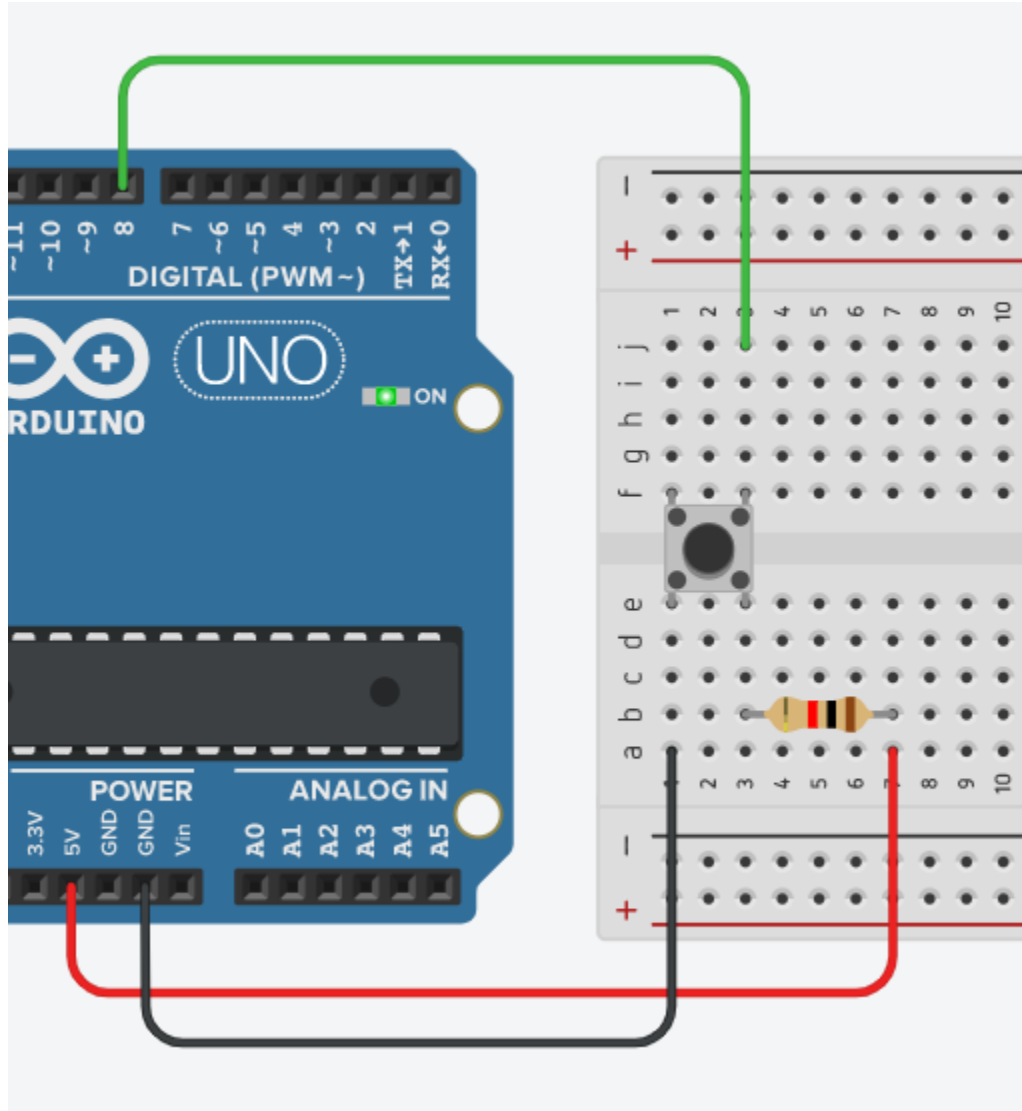
마그네틱 도어센서 실험



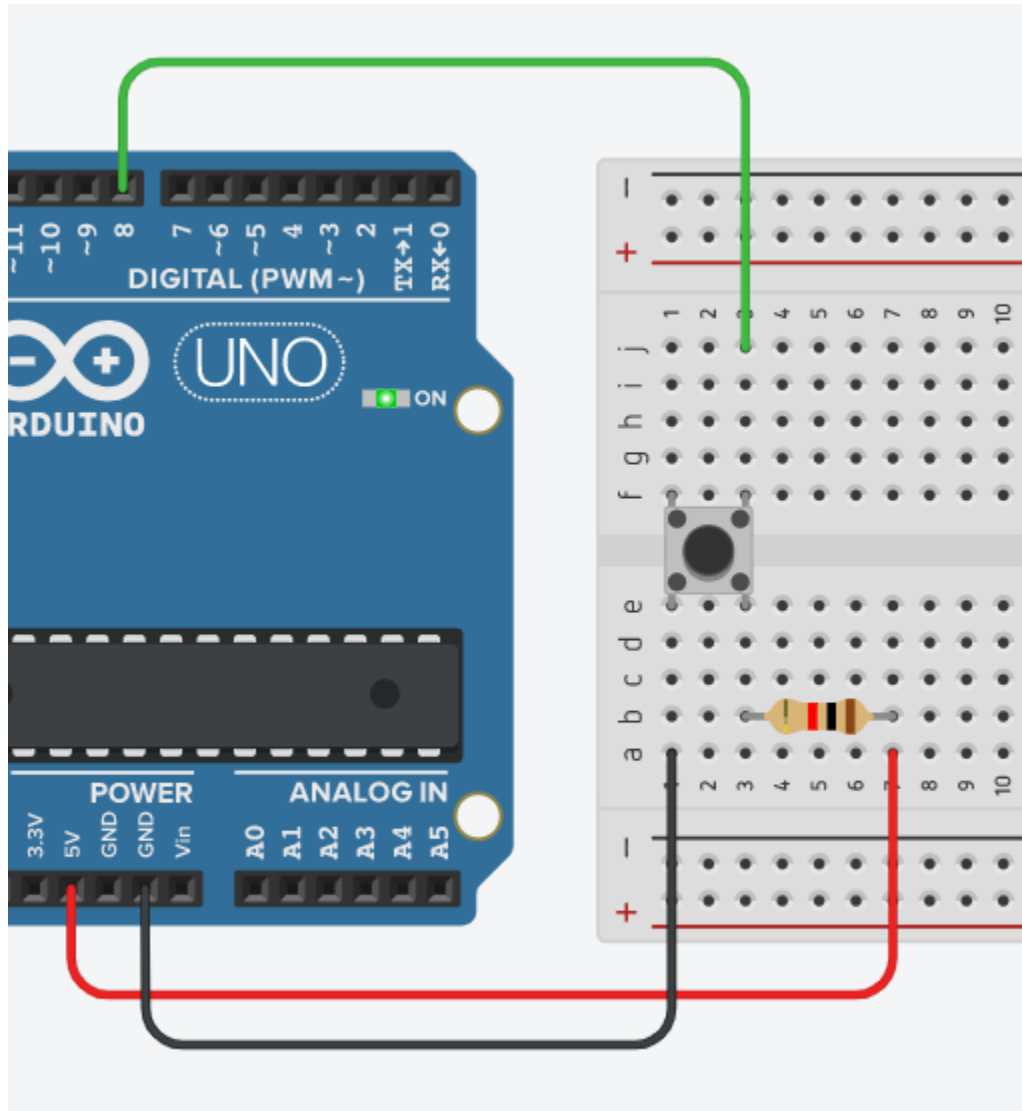
digitalRead



digitalRead



digitalRead

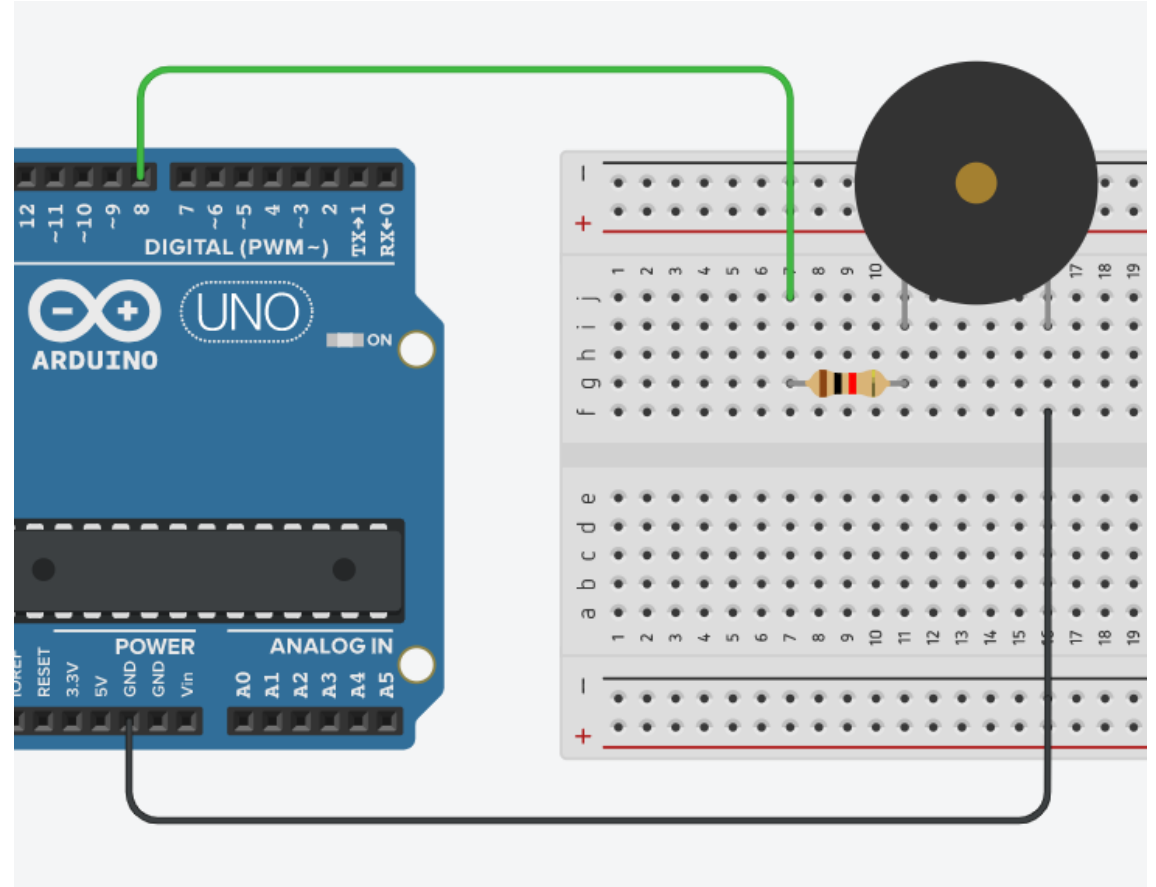


```
void setup()
{
  pinMode(8, INPUT) ;
  Serial.begin(9600) ;
}

void loop()
{
  int read = digitalRead(8) ;
  Serial.println(read) ;
}
```

부저 실험

- 부저(소리) 출력 실험
 - 부저 + <> 아두이노 8번핀
 - 부저 - <> 아두이노 GND



부저 + LED 실험

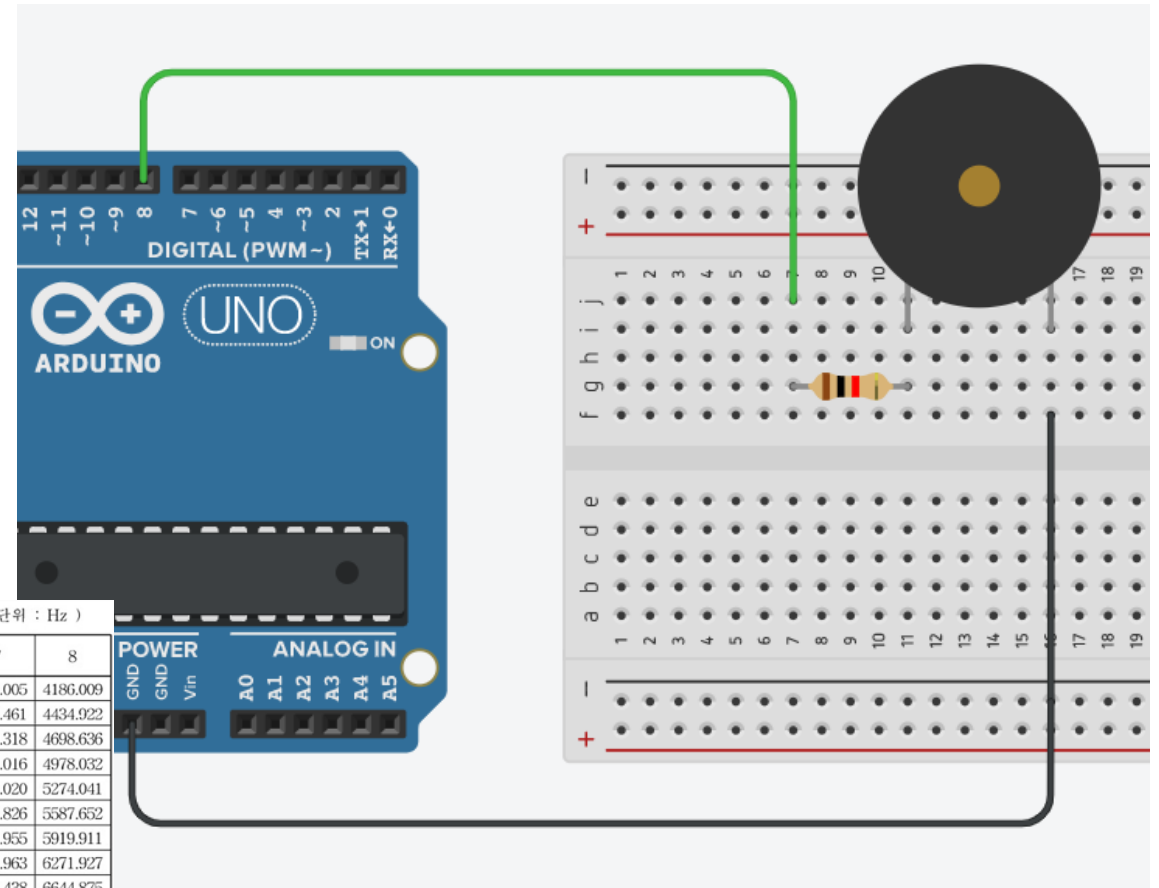
- 부저(소리) 출력 실험

```
void setup()
{
  pinMode(8, OUTPUT);
}

void loop()
{
  tone(8, 262, 500);
  delay(500);
}
```

(단위 : Hz)

음계 \ 옥타브	1	2	3	4	5	6	7	8
C(도)	32.7032	65.4064	130.8128	261.6256	523.2511	1046.502	2093.005	4186.009
C#	34.6478	69.2957	138.5913	277.1826	554.3653	1108.731	2217.461	4434.922
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D#	38.8909	77.7817	155.5635	311.1270	622.2540	1244.508	2489.016	4978.032
E(미)	41.2034	82.4069	164.8138	329.6276	659.2551	1318.510	2637.020	5274.041
F(파)	43.6535	87.3071	174.6141	349.2282	698.4565	1396.913	2793.826	5587.652
F#	46.2493	92.4986	184.9972	369.9944	739.9888	1479.978	2959.955	5919.911
G(솔)	48.9994	97.9989	195.9977	391.9954	783.9909	1567.982	3135.963	6271.927
G#	51.9130	103.8262	207.6523	415.3047	830.6094	1661.219	3322.438	6644.875
A(라)	55.0000	110.0000	220.0000	440.0000	880.0000	1760.000	3520.000	7040.000
A#	58.2705	116.5409	233.0819	466.1638	932.3275	1864.655	3729.310	7458.620
B(시)	61.7354	123.4708	246.9417	493.8833	987.7666	1975.533	3951.066	7902.133



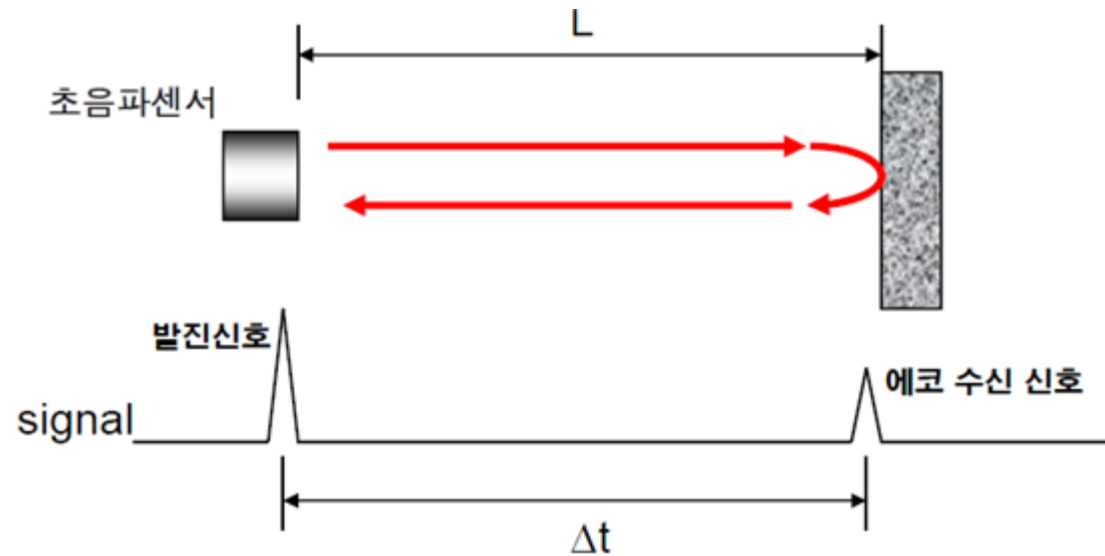
QUIZ



문이 열리면(버튼이 눌렸을 때) 경고음(부저)을 울려봅시다.

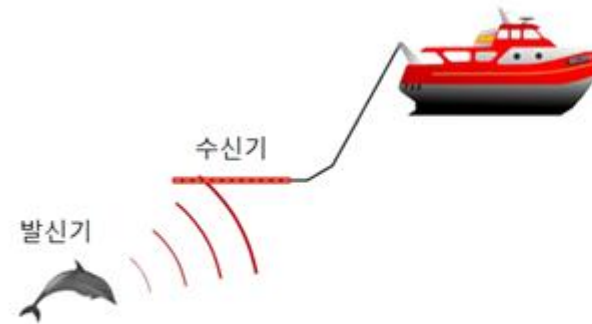
ToF(Time of Flight)

- **ToF**는 피사체를 향해 발사한 빛이나 소리가 반사돼 돌아오는 시간으로 거리를 계산해 사물의 입체감이나 공간 정보, 움직임 등을 인식하는 3D 센싱 기술이다



초음파 센서란?

- 초음파 센서는 인간이 들을 수 있는 범위를 벗어나 20,000Hz 이상의 음파를 사용해 센서로부터 지정된 목표 물체까지의 거리를 측정 및 계산하는 산업용 제어 장치.
- 음파는 기본적으로 고체, 액체 및 기체를 통과해 이동하는 압력파이고 거리를 측정하거나 표적이 있고 없음을 감지하기 위해 산업용 응용 분야에서 사용할 수 있다.



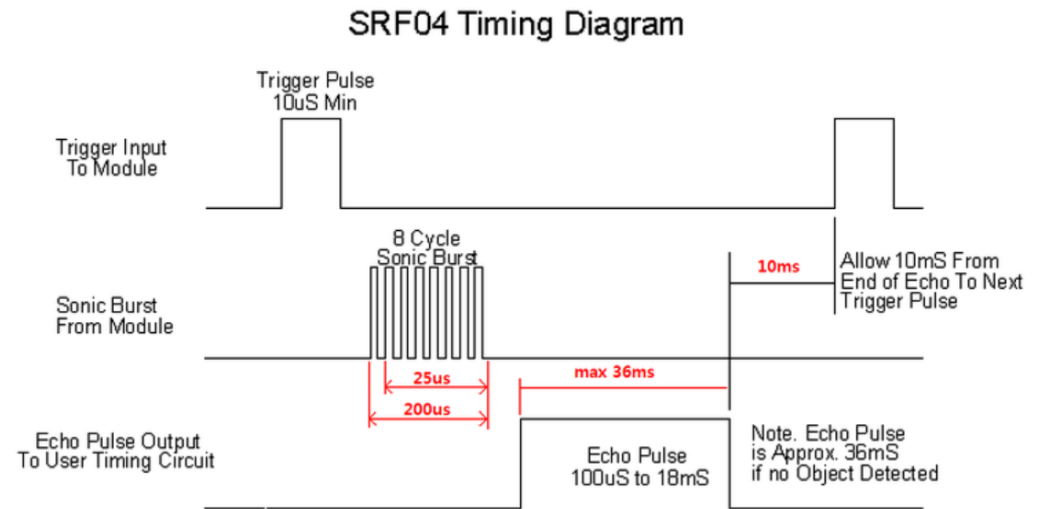
(a) 수동 소나(passive sonar)



(b) 능동 소나(active sonar)

초음파 센서 모듈

- SRF04 초음파 모듈을 사용하여 장애물까지의 거리 측정



초음파를 이용한 거리 측정

$$t = \frac{2 \times L(\text{물체와의 거리m})}{V_s(\text{음속m/s})}$$

t: 신호가 되돌아 올때까지 걸리는 시간(s)

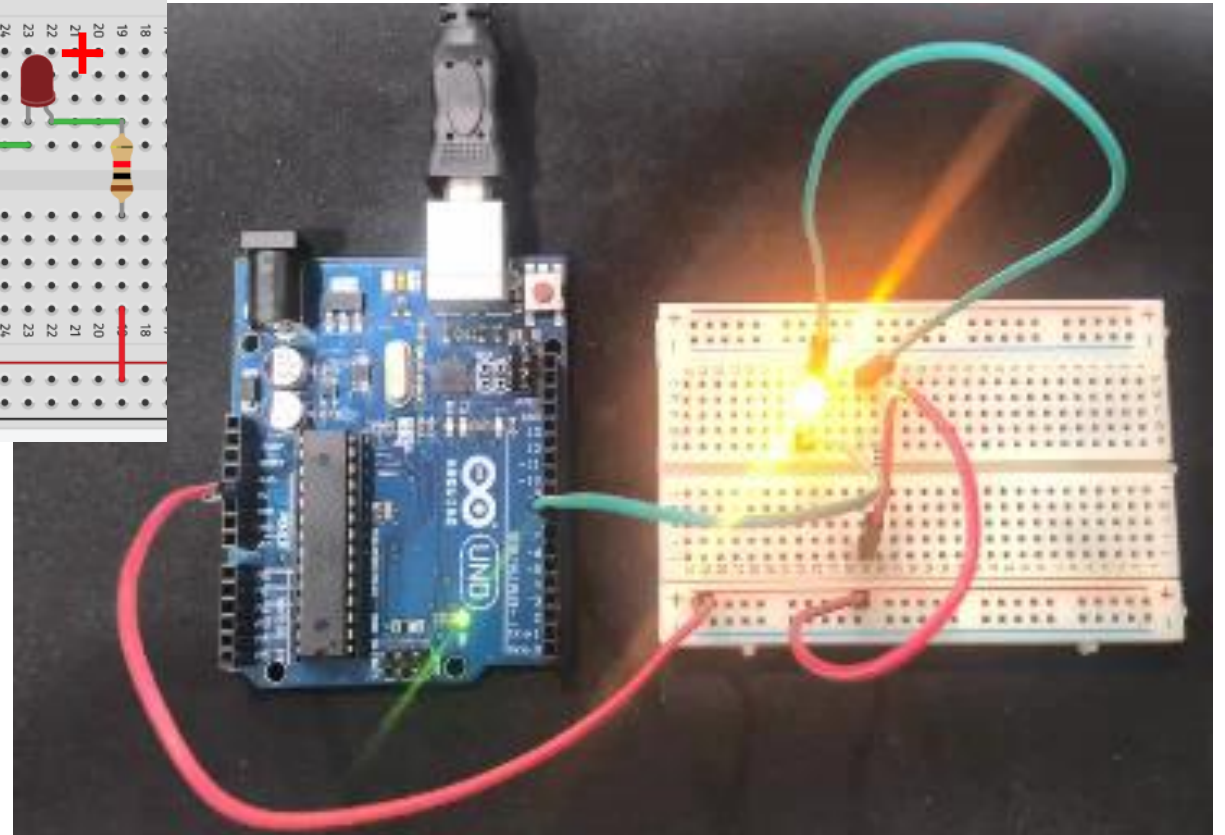
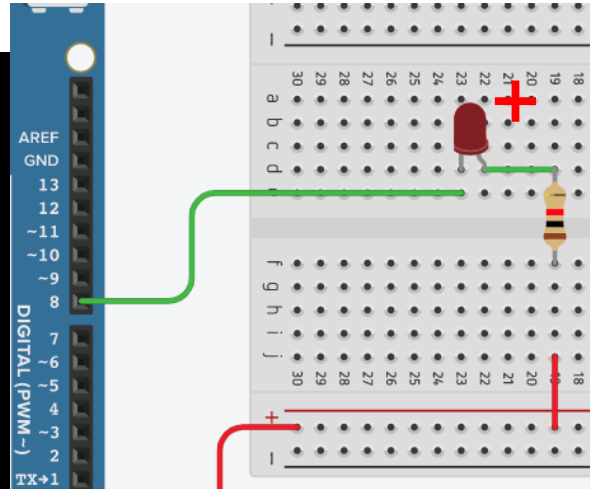
재료	속도 (m/s)
공기 (0℃)	331
공기 (20℃)	344
물 (25℃)	1498
목재 (소나무)	3300
유리	5000
철	5000
화강암	6000

LED를 이용한 digitalWrite 실험

- Arduino LED ON/OFF 실행

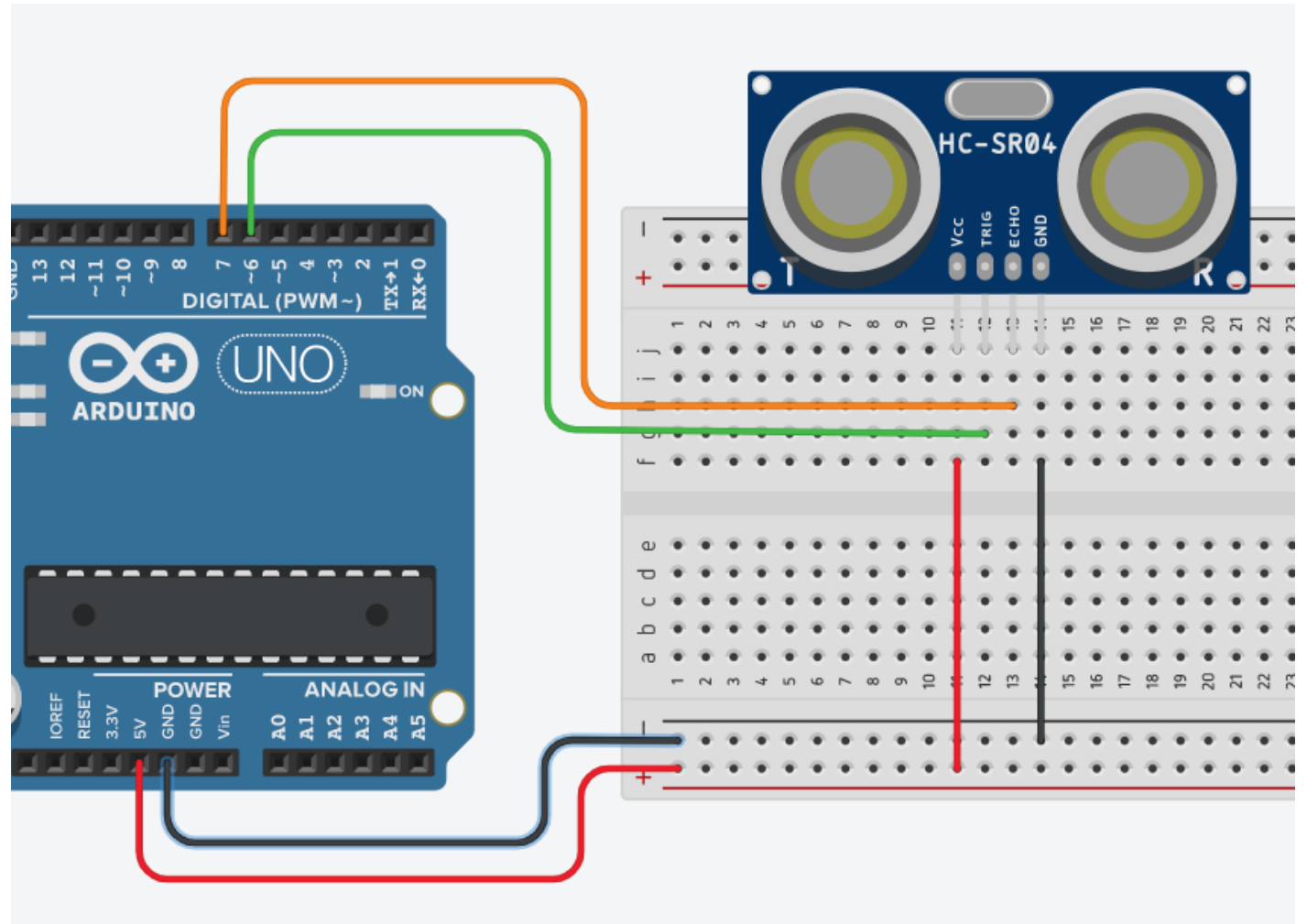
```
// C++ code
//
void setup()
{
  pinMode(8, OUTPUT);
}

void loop()
{
  digitalWrite(8, HIGH);
  delay(1000); // Wait for 1000 millisecond(s)
  digitalWrite(8, LOW);
  delay(1000); // Wait for 1000 millisecond(s)
}
```



아두이노를 이용한 초음파 센서 실험

- VCC ↔ 아두이노 5V
- GND ↔ 아두이노 GND
- TRIG ↔ 아두이노 6
- ECHO ↔ 아두이노 7



아두이노를 이용한 초음파 센서 실험

```
void setup()
{
    Serial.begin(9600) ;

    pinMode(6, OUTPUT);           //6 : Trigger
    pinMode(7, INPUT);           //7 : Echo
}

void loop()
{
    //trigger 발생
    digitalWrite(6, LOW) ;
    delayMicroseconds(2) ;
    digitalWrite(6, HIGH) ;
    delayMicroseconds(10) ;
    digitalWrite(6, LOW) ;

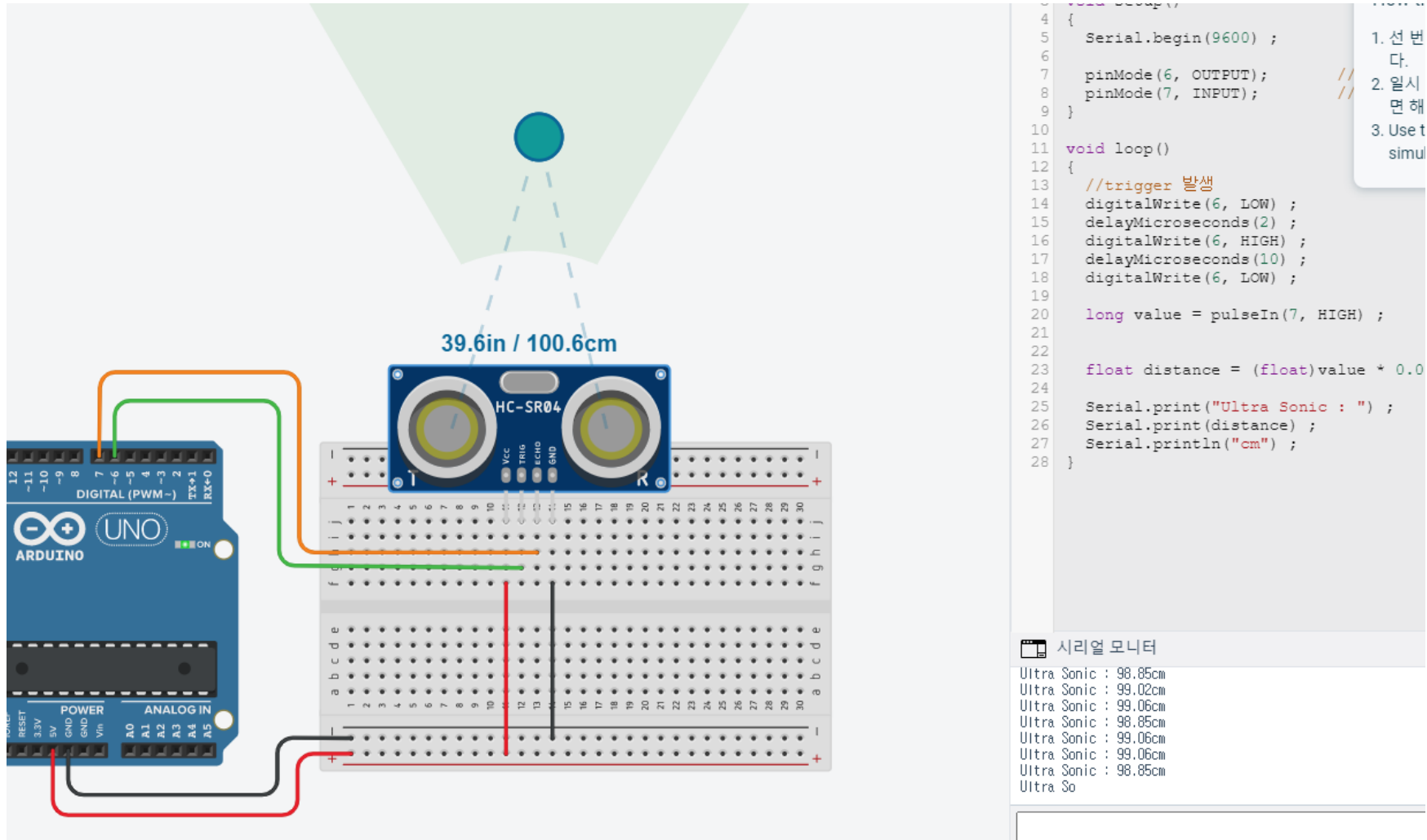
    long value = pulseIn(7, HIGH) ;

    float distance = (float)value * 0.01723 ;

    Serial.print("Ultra Sonic : ") ;
    Serial.print(distance) ;
    Serial.println("cm") ;
}
```

```
1  // C++ code
2  //
3  void setup()
4  {
5      Serial.begin(9600) ;
6
7      pinMode(6, OUTPUT);           //6 : Trigger
8      pinMode(7, INPUT);           //7 : Echo
9  }
10
11 void loop()
12 {
13     //trigger 발생
14     digitalWrite(6, LOW) ;
15     delayMicroseconds(2) ;
16     digitalWrite(6, HIGH) ;
17     delayMicroseconds(10) ;
18     digitalWrite(6, LOW) ;
19
20     long value = pulseIn(7, HIGH) ;
21
22
23     float distance = (float)value * 0.01723 ;
24
25     Serial.print("Ultra Sonic : ") ;
26     Serial.print(distance) ;
27     Serial.println("cm") ;
28 }
```

아두이노를 이용한 초음파 센서 실험



아두이노를 이용한 초음파 센서 실험

- QUIZ : 초음파 센서로 10cm이내에 장애물이 감지 되면 LED를 켜고 그렇지 않으면 LED를 끄는 회로와 프로그램을 완성 하시오.

