Arduino Lesson 6: Faking Analog Output with PWM

(Pulse Width Modulation)

Success Criteria

By the end of this lesson you should be able to:

- ❏ understand the effects on an LEDs output from changing the period
- ❏ understand the effects on an LEDs output from changing the duty cycle
- ❏ be able to explain the difference between the period and duty cycle

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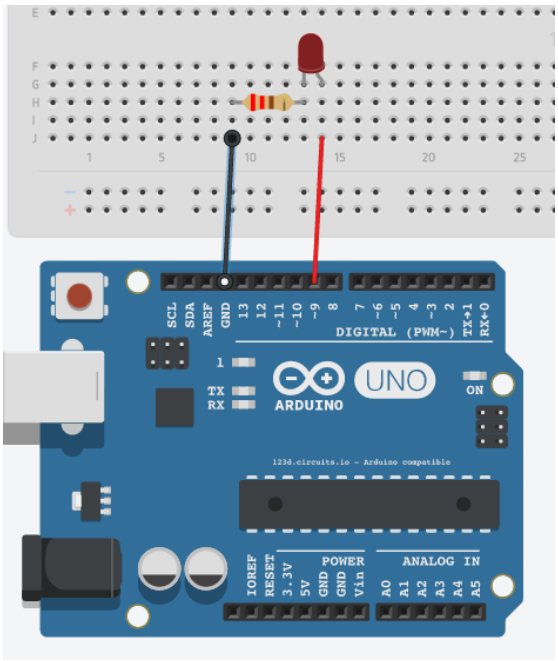
(Pulse Width Modulation)

Digital components can have two possible states: **on** or **off.** **Analog** components can have a wide range of states in between on and off (e.g. high, medium, low, etc.). An Arduino device is only capable of creating digital outputs (on or off). Controlling things such as light brightness or motor speed pose special challenges.

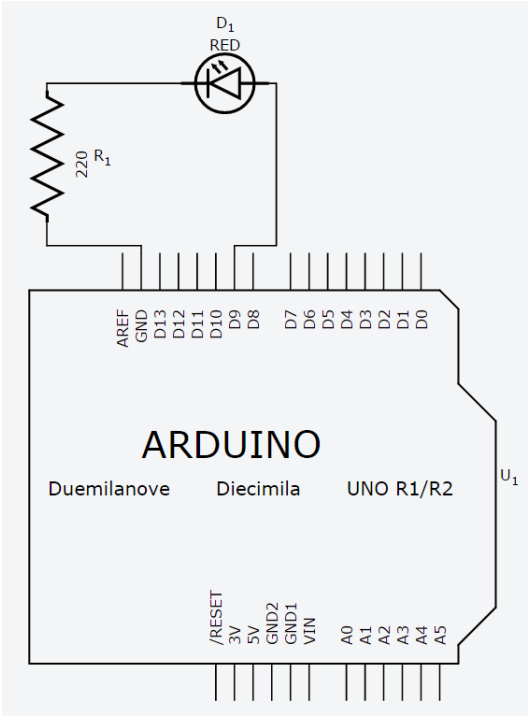
components:

• Arduino Uno	• red LED	• 220 Ω resistor	• hookup wires

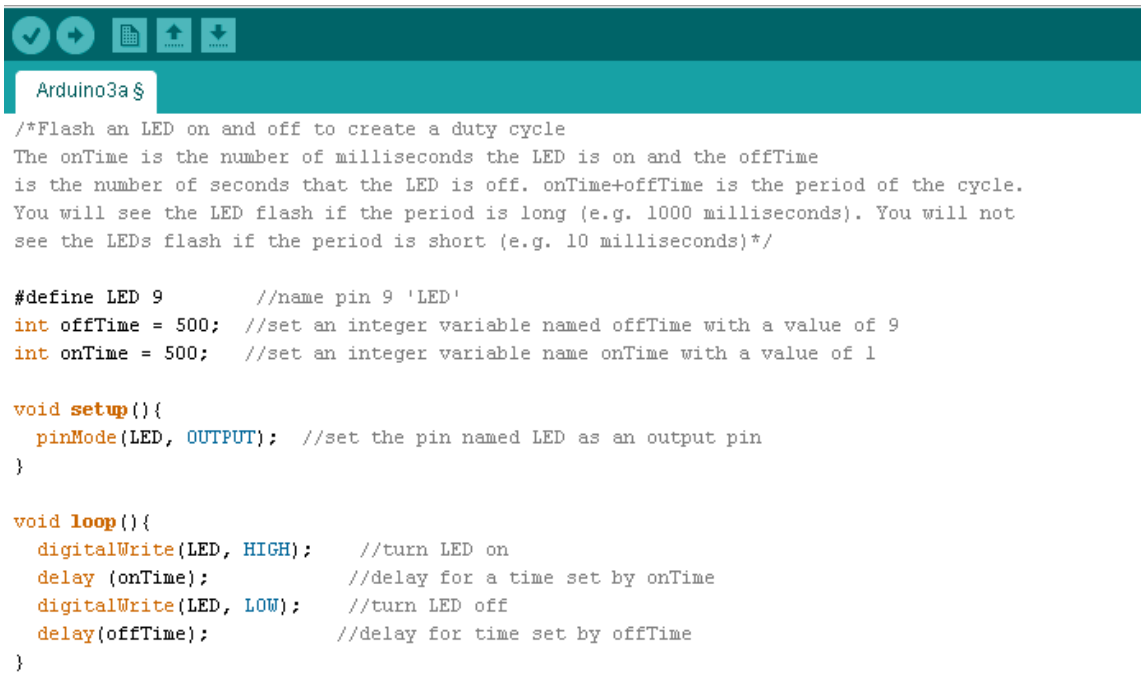
1) Build the circuit illustrated below



https://123d.circuits.io



2) Write the following program and download it to your Arduino UNO



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```
/*Flash an LED on and off to create a duty cycle
The onTime is the number of milliseconds the LED is on and the offTime
is the number of seconds that the LED is off. onTime+offTime is the period of the cycle.
You will see the LED flash if the period is long (e.g. 1000 milliseconds). You will not
see the LEDs flash if the period is short (e.g. 10 milliseconds)*/

#define LED 9         //name pin 9 'LED'
int offTime = 500;  //set an integer variable named offTime with a value of 9
int onTime = 500;   //set an integer variable name onTime with a value of 1

void setup(){
  pinMode(LED, OUTPUT);  //set the pin named LED as an output pin
}

void loop(){
  digitalWrite(LED, HIGH);    //turn LED on
  delay (onTime);             //delay for a time set by onTime
  digitalWrite(LED, LOW);     //turn LED off
  delay(offTime);            //delay for time set by offTime
}
```

3) Change the values of `offTime` and `onTime` to the ones in the table below, download the program and note the difference in the performance of the LED in the tables on the lab observations page 4.

	one second period	**100 millisecond period**	**10 millisecond period**

low 10%	digitalWrite(LED, HIGH);
	delay (**100**);
	digitalWrite(LED, LOW);
	delay (**900**);
		digitalWrite(LED, HIGH);
		delay (**10**);
		digitalWrite(LED, LOW);
		delay (**90**);
			digitalWrite(LED, HIGH);
			delay (**1**);
			digitalWrite(LED, LOW);
			delay (**9**);

medium 50%	digitalWrite(LED, HIGH);
	delay (**500**);
	digitalWrite(LED, LOW);
	delay (**500**);
		digitalWrite(LED, HIGH);
		delay (**50**);
		digitalWrite(LED, LOW);
		delay (**50**);
			digitalWrite(LED, HIGH);
			delay (**5**);
			digitalWrite(LED, LOW);
			delay (**5**);

high 90%	digitalWrite(LED, HIGH);
	delay (**900**);
	digitalWrite(LED, LOW);
	delay (**100**);
		digitalWrite(LED, HIGH);
		delay (**90**);
		digitalWrite(LED, LOW);
		delay (**10**);
			digitalWrite(LED, HIGH);
			delay (**9**);
			digitalWrite(LED, LOW);
			delay (**1**);

Observations Page:

4) Note the difference in the performance of the LED in the tables on the lab observations page. BE DESCRIPTIVE! (brightness of the LED, whether or not it flashes, and if so, how quickly):

	one second period	**Observations**

low 10%	digitalWrite(LED, HIGH);
	delay (**100**);
	digitalWrite(LED, LOW);
	delay (**900**);
		Regular brightness of the LED is shown
		No dimmed light from the LED
		The LED stays off for a while before quickly flashing on once every second

medium 50%	digitalWrite(LED, HIGH);
	delay (**500**);
	digitalWrite(LED, LOW);
	delay (**500**);
		Regular brightness of the LED is maintained
		No dimmed light from the LED
		The LED flashes at a moderate pace (Light stays on for the same time before it turns off every second)

high 90%	digitalWrite(LED, HIGH);
	delay (**900**);
	digitalWrite(LED, LOW);
	delay (**100**);
		Regular brightness of the LED is maintained
		No dimmed light from the LED
		The LED is mainly on aside from the occasional quick flash off every second.

	100 millisecond period	**Observations**

low 10%	digitalWrite(LED, HIGH);
	delay (**10**);
	digitalWrite(LED, LOW);
	delay (**90**);
		Slightly dim in comparison to the regular brightness of the LED
		The LED flashes numerous times per second at a very quick pace that allows for a visible transition from off to on.

medium 50%	digitalWrite(LED, HIGH);
	delay (**50**);
	digitalWrite(LED, LOW);
	delay (**50**);
		Regular brightness of LED is shown
		LED mainly stays on with a steady pace of flashes (akin to flashing police car LEDs)

high 90%	digitalWrite(LED, HIGH);
	delay (**90**);
	digitalWrite(LED, LOW);
	delay (**10**);
		Regular brightness of LED is maintained
		The LED almost always stays on with negligible flashes when it offs (Akin to the flicker of a fire when it dies down a bit)
		Difficult to tell when the LED ons and offs

	10 millisecond period	**Observations**

low 10%	digitalWrite(LED, HIGH);
	delay (**1**);
	digitalWrite(LED, LOW);
	delay (**9**);
		The LED is slightly dim in comparison to its regular brightness
		The LED stays on without any visible flicker

medium 50%	digitalWrite(LED, HIGH);
	delay (**5**);
	digitalWrite(LED, LOW);
		Regular brightness of the LED is shown
		The LED stays on without any visible flicker

	delay (**5**);	

high 90%	digitalWrite(LED, HIGH);
	delay (**9**);
	digitalWrite(LED, LOW);
	delay (**1**);
		Regular brightness of the LED is maintained
		The LED stays on without any visible flicker