

Take Our Children To Work Day – 2013

~~Introduction to Microcontrollers~~ Wizardsing 101

Plan for today

- YOU are going to write programs and make things happen!

*Any sufficiently advanced technology
is indistinguishable from magic.*

Arthur C. Clarke

Rules for today

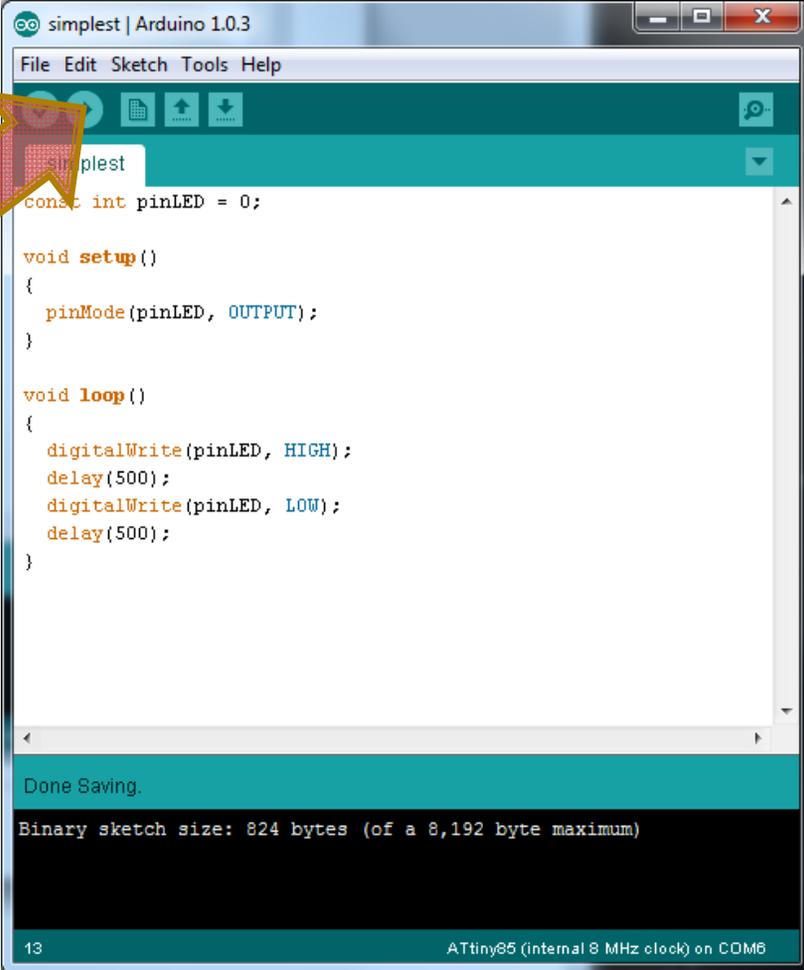
- Raise your hand to ask questions. No dumb questions.
- Be respectful of others.
- When you hear me clap, stop talking, and look up.
- Don't run other programs on the computer other than the one we have up now.
- Take turns typing on the computer with your partner.
- Have fun!

First, plug it in...

- Plug in the USB programmer
- You should see the lights blink in order.
 - (called LED for Light Emitting diode)
- Everyone there?

Our first program

- Go to File..Sketchbook..Simplest
- Click the round button with the arrow (upload)
- You'll see some messages, rapid blinking lights. Then the first LED (LEDo) will blink.
- Everyone there?



```
simplest | Arduino 1.0.3
File Edit Sketch Tools Help
simplest
const int pinLED = 0;

void setup()
{
  pinMode(pinLED, OUTPUT);
}

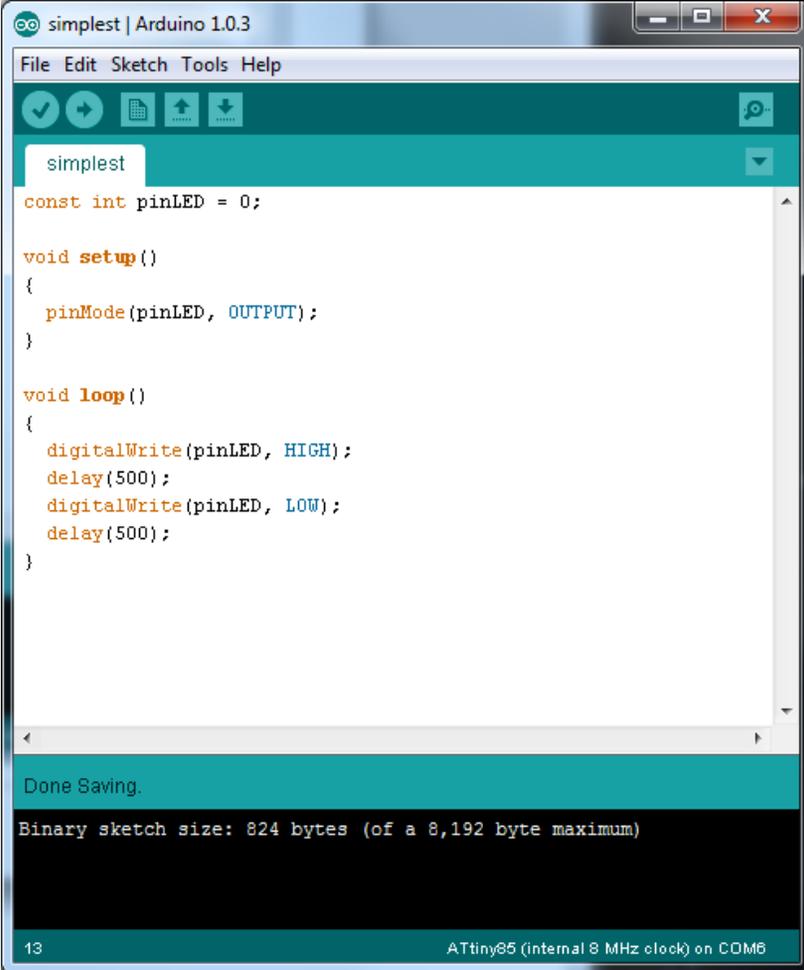
void loop()
{
  digitalWrite(pinLED, HIGH);
  delay(500);
  digitalWrite(pinLED, LOW);
  delay(500);
}

Done Saving.
Binary sketch size: 824 bytes (of a 8,192 byte maximum)

13 ATtiny85 (internal 8 MHz clock) on COM6
```

Our first program explained (1 of 2)

- `const int pinLED = 0;`
 - We have four LEDs. Programmers start counting with 0. (Why waste a number?) We have LED₀, LED₁, LED₂, LED₃.
 - This replaces pinLED with 0 everywhere in our program.
- Why would we do this?
- Change it to say `const int pinLED = 1;` and upload it.
- Now a different LED is blinking....
- Go ahead and change it back and upload it so the first LED is blinking again.



```
simplest | Arduino 1.0.3
File Edit Sketch Tools Help
simplest
const int pinLED = 0;

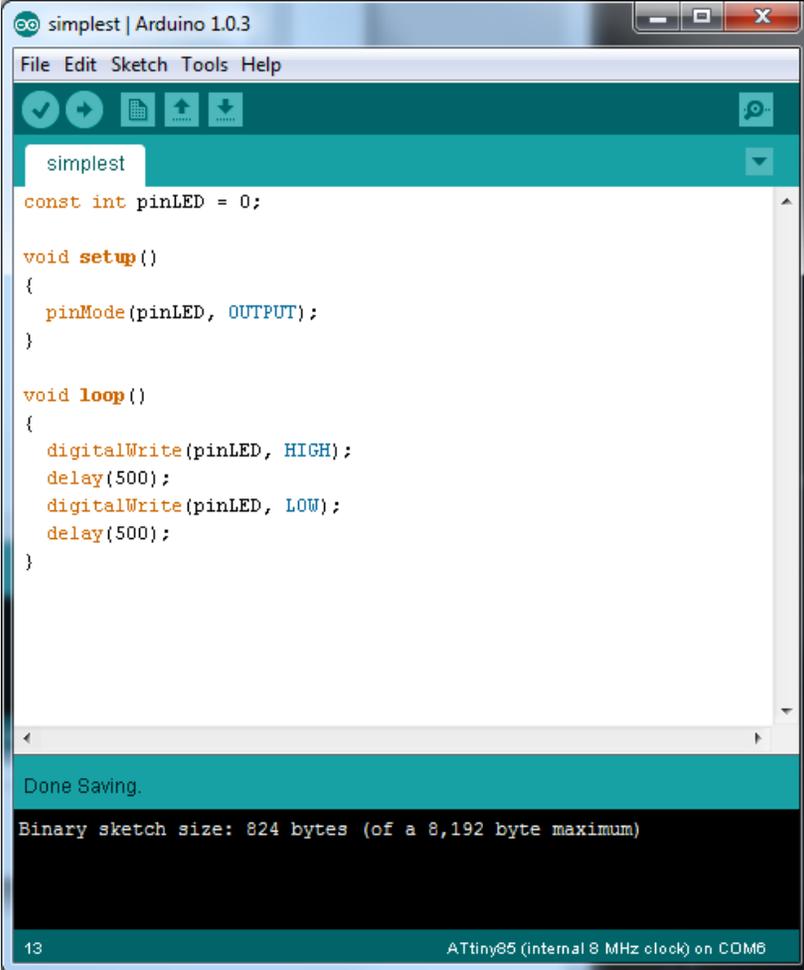
void setup()
{
  pinMode(pinLED, OUTPUT);
}

void loop()
{
  digitalWrite(pinLED, HIGH);
  delay(500);
  digitalWrite(pinLED, LOW);
  delay(500);
}

Done Saving.
Binary sketch size: 824 bytes (of a 8,192 byte maximum)
13 ATtiny85 (internal 8 MHz clock) on COM6
```

Our first program explained (2 of 2)

- `setup` is called once (at the very beginning)
 - `pinMode` – sets a pin of the microcontroller to be either OUTPUT (we control) or INPUT (we read)
- `loop` is then called. Everytime after loop finishes, it is called again (and again and again and again....)
 - `digitalWrite` – HIGH will turn on the LED, LOW will turn it off
 - `delay` – number of milliseconds to wait (a millisecond is $1/1000^{\text{th}}$ of a second. So 500 is $500/1000^{\text{th}}$ or $1/2$ of a second)
- If we change the number in `delay` to 100, will it blink faster or slower?
- Try it...



```
simplest | Arduino 1.0.3
File Edit Sketch Tools Help
simplest
const int pinLED = 0;

void setup()
{
  pinMode(pinLED, OUTPUT);
}

void loop()
{
  digitalWrite(pinLED, HIGH);
  delay(500);
  digitalWrite(pinLED, LOW);
  delay(500);
}

Done Saving.
Binary sketch size: 824 bytes (of a 8,192 byte maximum)
13 ATtiny85 (internal 8 MHz clock) on COM6
```

Some “gotchas”

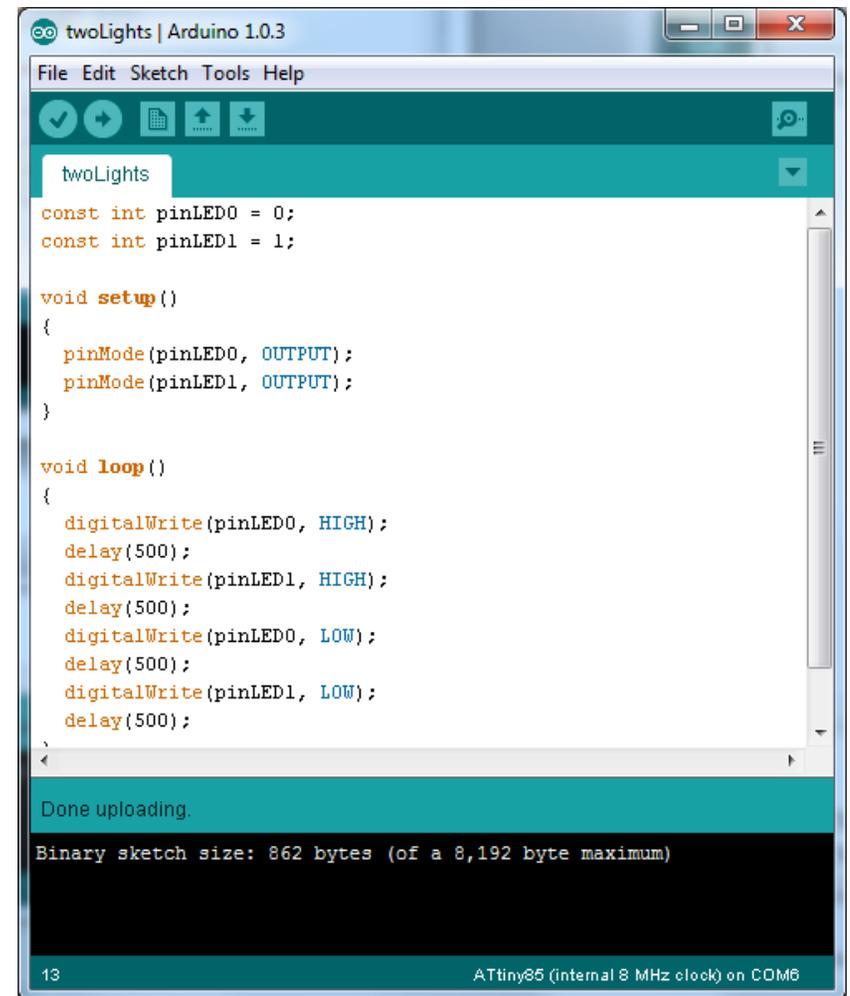
- Program isn't working. Some common problems.
 - Case matters. So PIN is not the same as pin. (or pIn or Pin or....)
 - Forgetting semi-colon “;” at end of the line
 - Parentheses in the wrong place
 - Using a “=” when you meant “==”

Challenge #0

- Change the program so it blinks on for 1 second (1000 ms) and off for $\frac{1}{2}$ a second (500 ms).
 - When you have it, raise your hand for us to come look.
 - (after you have shown it to us, you can make other patterns)
 - If you are stuck, raise your hand for help.
 - GO!

Let's do two lights....

- What do you think will happen?
- Sketchbook..twoLights
- upload it to your board.



The screenshot shows the Arduino IDE interface for a sketch named 'twoLights'. The code defines two pins, pinLED0 (0) and pinLED1 (1), and sets them as outputs. The setup function initializes the pins. The loop function toggles both LEDs on and off with 500ms delays. The IDE shows the upload is complete, with a binary sketch size of 862 bytes. The target board is identified as ATtiny85.

```
twoLights | Arduino 1.0.3
File Edit Sketch Tools Help
twoLights
const int pinLED0 = 0;
const int pinLED1 = 1;

void setup()
{
  pinMode(pinLED0, OUTPUT);
  pinMode(pinLED1, OUTPUT);
}

void loop()
{
  digitalWrite(pinLED0, HIGH);
  delay(500);
  digitalWrite(pinLED1, HIGH);
  delay(500);
  digitalWrite(pinLED0, LOW);
  delay(500);
  digitalWrite(pinLED1, LOW);
  delay(500);
}

Done uploading.
Binary sketch size: 862 bytes (of a 8,192 byte maximum)
13 ATtiny85 (internal 8 MHz clock) on COM6
```

Challenge #1

- Expand your twoLights program to turn on and off all four LEDs (they are on pins 0, 1, 2, 3)
 - When you have it, raise your hand for us to come look.
 - (after you have shown it to us, you can make other patterns)
 - If you are stuck, raise your hand for help.
 - GO!

There is also a pushbutton...

- `setup`
 - We setup the `pinButton` to be an INPUT (read from outside world)
 - The `digitalWrite` is unusual here. It turns on a pull-up resistor so a push button will work without additional electronics.
- `loop`
 - `digitalRead` will return LOW if the button is pressed and HIGH if it isn't pressed
 - We can make decisions based off of this and execute different code
- Sketchbook..simple_button
- Upload it to your board



```
simple_button | Arduino 1.0.3
File Edit Sketch Tools Help
simple_button
const int pinLED = 0;
const int pinButton = 4;

void setup()
{
  pinMode(pinLED, OUTPUT);
  pinMode(pinButton, INPUT);
  digitalWrite(pinButton, HIGH); // turn on pull-up resistor
}

void loop()
{
  if(digitalRead(pinButton) == LOW){
    digitalWrite(pinLED, HIGH);
  }
  else{
    digitalWrite(pinLED, LOW);
  }
}

Done Saving.

2 ATtiny85 (internal 8 MHz clock) on COM6
```

Challenge #2

- Make a program that blinks LED₀ if the pushbutton is pressed and LED₁ if it isn't.
 - When you have it, raise your hand for us to come look.
 - (after you have shown it to us, you can make other patterns)
 - If you are stuck, raise your hand for help.
 - GO!

For Statement

- A `for` statement allows us to do things multiple times.
- We give it a starting value, a condition to check, and something to do after each time through.
 - (`i++` means `I = I + 1`)
- Sketchbook..blinkFor
- Upload it to your board
- Change the 4 to 8
- Upload it to your board



```
blinkFor | Arduino 1.0.3
File Edit Sketch Tools Help
blinkFor
const int pinLEDO = 0;

void setup()
{
  pinMode(pinLEDO, OUTPUT);
}

void loop()
{
  for(int i = 0; i < 4; i++){
    digitalWrite(pinLEDO, HIGH);
    delay(200);
    digitalWrite(pinLEDO, LOW);
    delay(200);
  }
  delay(1000);
}

Done Saving.

Binary sketch size: 854 bytes (of a 8,192 byte maximum)

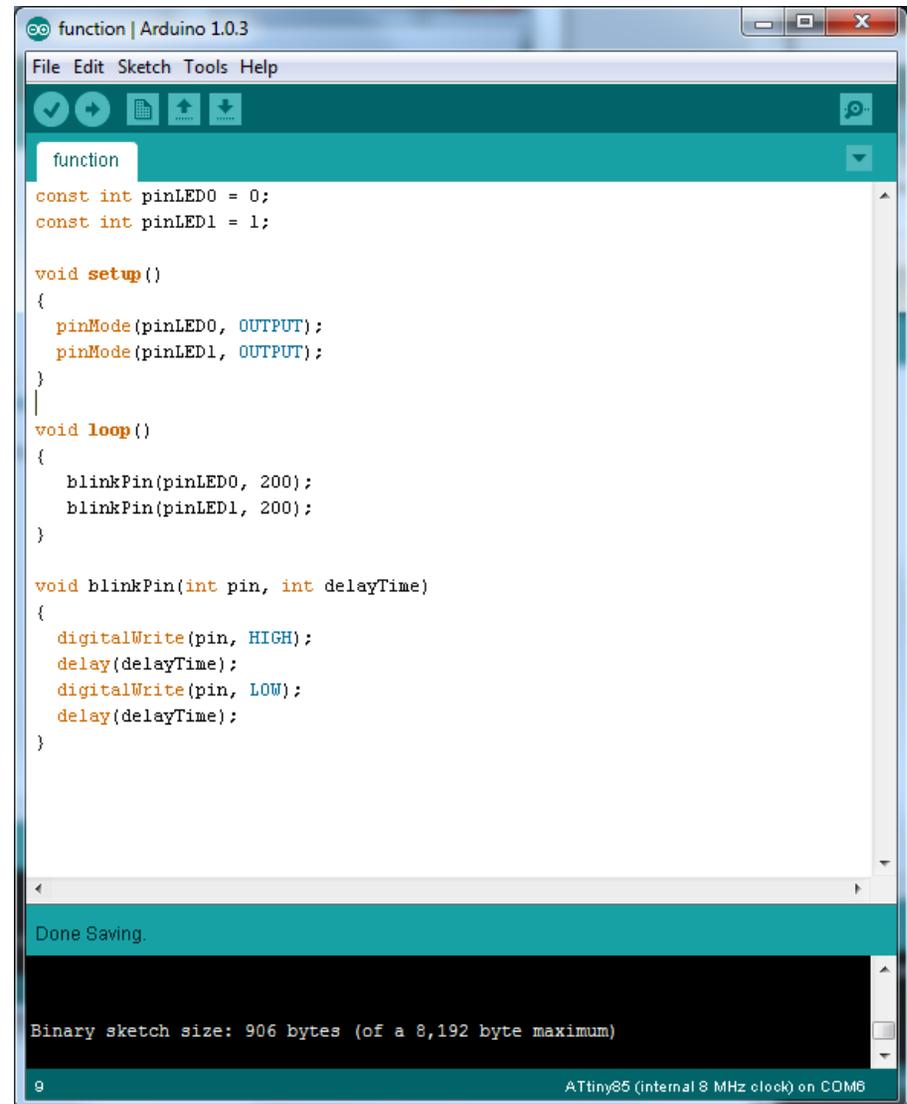
1 ATTiny85 (internal 8 MHz clock) on COM6
```

Challenge #3

- Make a program that blinks LED₀ four times in a row, and then LED₁ four times in a row. Then it should repeat.
 - When you have it, raise your hand for us to come look.
 - (after you have shown it to us, you can make other patterns)
 - If you are stuck, raise your hand for help.
 - GO!

Making functions

- Good programmers are lazy
- We can make new functions and then call them.
- Sketchbook..function
- Upload it to your board
- Change it to also blink LEDs 2 & 3.
- Upload it to your board



```
function | Arduino 1.0.3
File Edit Sketch Tools Help
function
const int pinLEDO = 0;
const int pinLED1 = 1;

void setup()
{
  pinMode(pinLEDO, OUTPUT);
  pinMode(pinLED1, OUTPUT);
}

void loop()
{
  blinkPin(pinLEDO, 200);
  blinkPin(pinLED1, 200);
}

void blinkPin(int pin, int delayTime)
{
  digitalWrite(pin, HIGH);
  delay(delayTime);
  digitalWrite(pin, LOW);
  delay(delayTime);
}

Done Saving.

Binary sketch size: 906 bytes (of a 8,192 byte maximum)

9 ATtiny85 (internal 8 MHz clock) on COM6
```

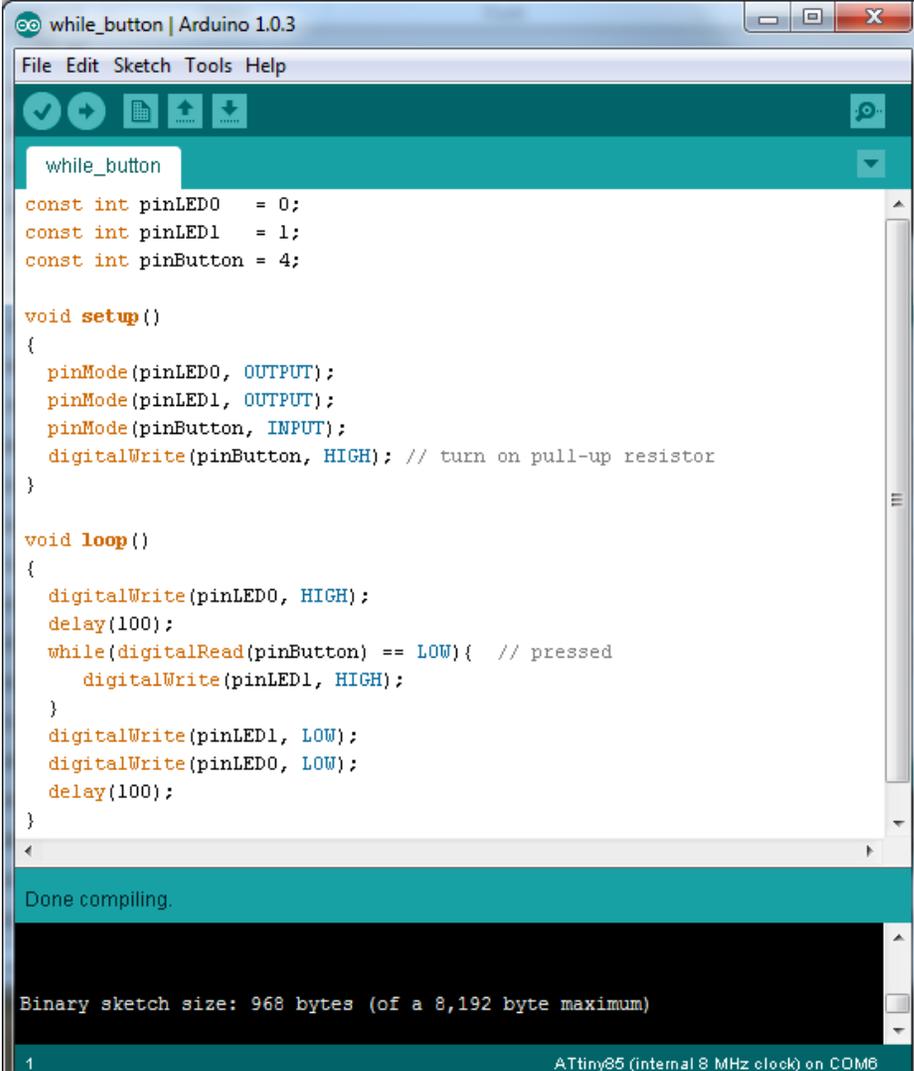
Challenge #4

- Make two functions. One that is "Dash" and one that is "Dot".
- The Dash should have the LED on for 750ms (and off for 250). The Dot should have the light on for 250ms (and off for 750ms). In between each letter, the LED should be off for 1/2 second. (500 ms)
- Now have your program send SOS (...---...)
- 2 seconds (2000 ms) with all lights off between sending SOS.
 - When you have it, raise your hand for us to come look.
 - (after you have shown it to us, you can make other patterns)
 - If you are stuck, raise your hand for help.
 - GO!

While statement

- A `while` statement is like an `if`, but it goes back and checks the condition again after the code has executed.
- Sketchbook..while_button
- Upload it to your board
- HINT: Your program is really doing:

```
setup( );  
while(TRUE) {  
    loop( );  
}
```



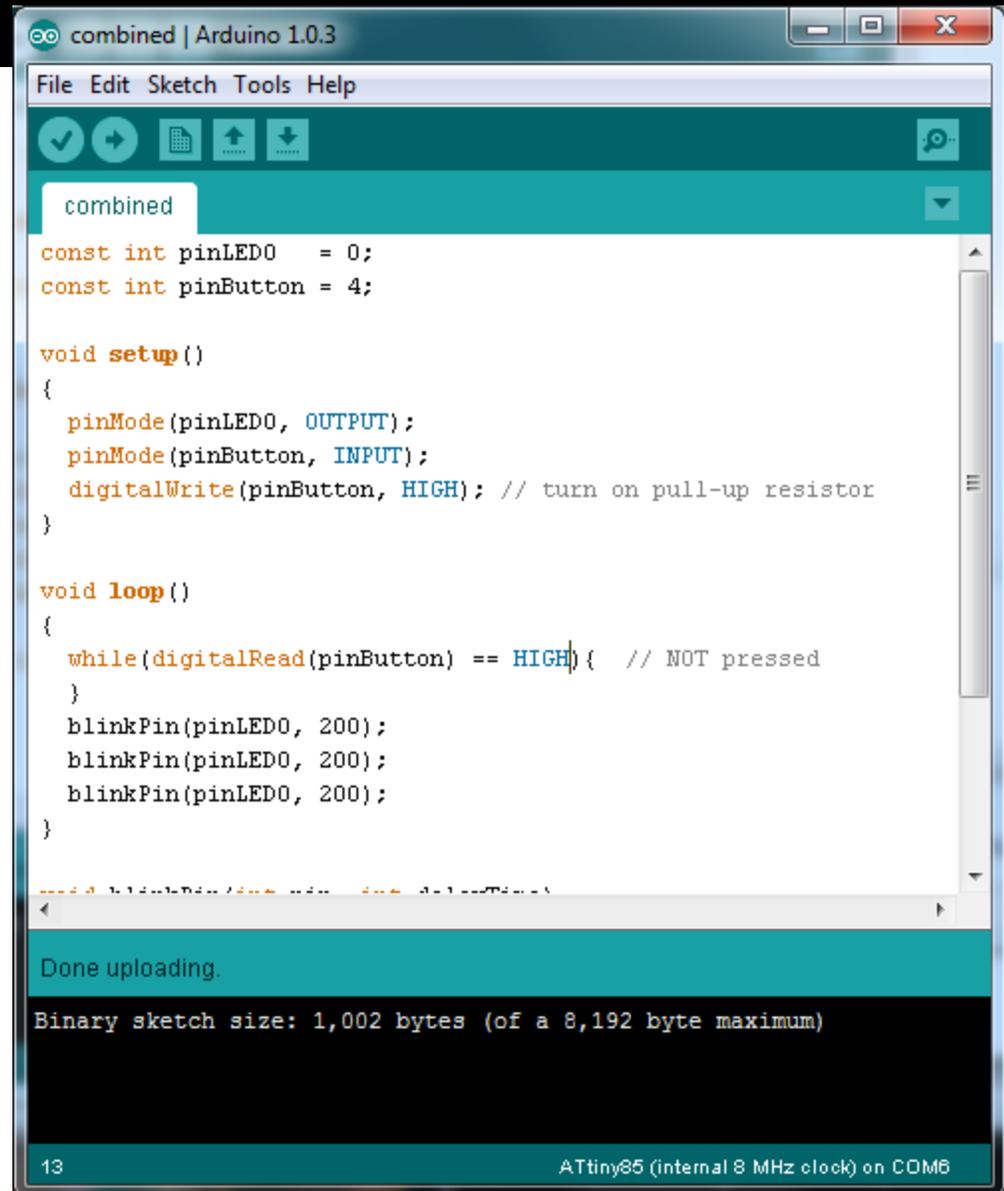
```
while_button | Arduino 1.0.3  
File Edit Sketch Tools Help  
while_button  
const int pinLEDO = 0;  
const int pinLED1 = 1;  
const int pinButton = 4;  
  
void setup()  
{  
    pinMode(pinLEDO, OUTPUT);  
    pinMode(pinLED1, OUTPUT);  
    pinMode(pinButton, INPUT);  
    digitalWrite(pinButton, HIGH); // turn on pull-up resistor  
}  
  
void loop()  
{  
    digitalWrite(pinLEDO, HIGH);  
    delay(100);  
    while(digitalRead(pinButton) == LOW){ // pressed  
        digitalWrite(pinLED1, HIGH);  
    }  
    digitalWrite(pinLED1, LOW);  
    digitalWrite(pinLEDO, LOW);  
    delay(100);  
}  
  
Done compiling.  
  
Binary sketch size: 968 bytes (of a 8,192 byte maximum)  
1  
ATtiny85 (internal 8 MHz clock) on COM6
```

Challenge #5

- Make a program that blinks LED while the button isn't pressed, and turns on all LEDs while the button is pressed.
 - When you have it, raise your hand for us to come look.
 - (after you have shown it to us, you can make other patterns)
 - If you are stuck, raise your hand for help.
 - GO!

We Combine Things...

- When button is pressed, blink 3 times and then go back to waiting for the button to be pressed.
- Sketchbook...Combined
- Upload it to your board



```
combined | Arduino 1.0.3
File Edit Sketch Tools Help
combined
const int pinLEDO = 0;
const int pinButton = 4;

void setup()
{
  pinMode(pinLEDO, OUTPUT);
  pinMode(pinButton, INPUT);
  digitalWrite(pinButton, HIGH); // turn on pull-up resistor
}

void loop()
{
  while(digitalRead(pinButton) == HIGH){ // NOT pressed
  }
  blinkPin(pinLEDO, 200);
  blinkPin(pinLEDO, 200);
  blinkPin(pinLEDO, 200);
}

Done uploading.
Binary sketch size: 1,002 bytes (of a 8,192 byte maximum)
13 ATtiny85 (internal 8 MHz clock) on COM6
```

Challenge #6

- Make it send SOS (... --- ...) when your button is pressed.
- When you have it, raise your hand for us to come look.
 - (after you have shown it to us, you can make other patterns)
 - If you are stuck, raise your hand for help.
 - GO!

Using Variables...

- Use the button to change which light is blinking.
- Sketchbook...step
- Upload it to your board



```
step | Arduino 1.0.3
File Edit Sketch Tools Help
step
const int pinLEDO = 0;
const int pinLED1 = 1;
const int pinButton = 4;

void setup()
{
  pinMode(pinLEDO, OUTPUT);
  pinMode(pinLED1, OUTPUT);
  pinMode(pinButton, INPUT);
  digitalWrite(pinButton, HIGH); // turn on pull-up resistor
}
int pinToBlink = 0;
void loop()
{
  if(digitalRead(pinButton) == LOW){ // pressed
    pinToBlink = pinToBlink + 1;
    if(pinToBlink > 1){
      pinToBlink = 0;
    }
  }
  if(pinToBlink == 0){
    blinkPin(pinLEDO, 500);
  }
  if(pinToBlink == 1){
    blinkPin(pinLED1, 500);
  }
}
void blinkPin(int pin, int delayTime)
{
  digitalWrite(pin, HIGH);
  delay(delayTime);
  digitalWrite(pin, LOW);
  delay(delayTime);
}

Done compiling.

Binary sketch size: 1,052 bytes (of a 8,192 byte maximum)
```

Challenge #7

- Make it so pressing the button makes the next LED blink. (using all 4 LEDs)
- When you have it, raise your hand for us to come look.
 - (after you have shown it to us, you can make other patterns)
 - If you are stuck, raise your hand for help.
 - GO!

Other Challenges...

- Have it send Morse Code for your name
- Make a light pattern that starts out slow and gets faster.
- Make a light pattern that changes speed when the button is pressed
- Make light patterns where multiple lights blink at different speeds.

International Morse Code

1. The length of a dot is one unit.
2. A dash is three units.
3. The space between parts of the same letter is one unit.
4. The space between letters is three units.
5. The space between words is seven units.

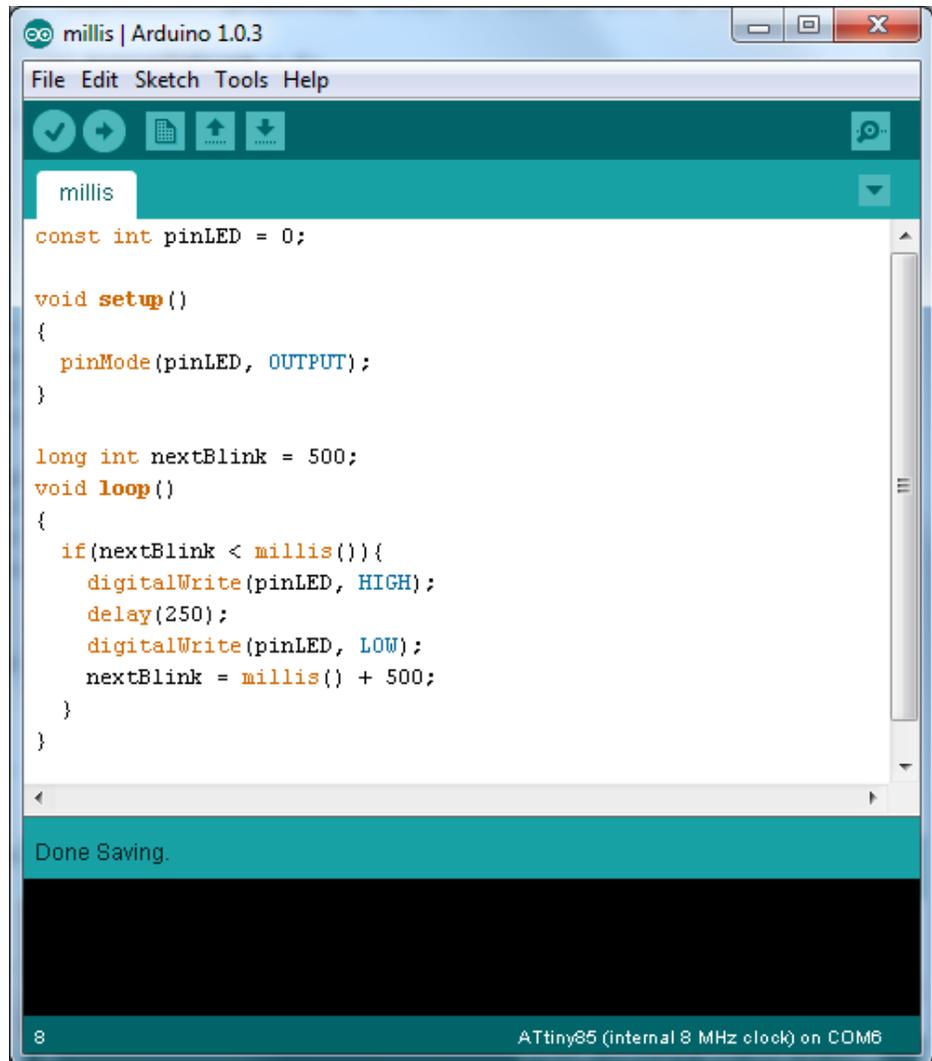
A ● —
B — ● ● ●
C — ● — ●
D — ● ●
E ●
F ● ● — ●
G — — ●
H ● ● ● ●
I ● ●
J ● — — —
K — ● —
L ● — ● ●
M — —
N — ●
O — — —
P ● — — ●
Q — — ● —
R ● — ●
S ● ● ●
T —

U ● ● —
V ● ● ● —
W ● — —
X — ● ● —
Y — ● — —
Z — — ● ●

1 ● — — — —
2 ● ● — — —
3 ● ● ● — —
4 ● ● ● ● —
5 ● ● ● ● ●
6 — ● ● ● ●
7 — — ● ● ●
8 — — — ● ●
9 — — — — ●
0 — — — — —

Bonus Information

- Problem with delay() – it means you can't do anything while you are waiting.
- You can call millis() which returns a long int with the number of milliseconds your program has been running.
 - On this chip, int is 16 bits (-32,766 to 32,767)
 - Long it is 32 bits (-2,147,483,646 to 2,147,483,647)



```
millis | Arduino 1.0.3
File Edit Sketch Tools Help
millis
const int pinLED = 0;

void setup()
{
  pinMode(pinLED, OUTPUT);
}

long int nextBlink = 500;
void loop()
{
  if(nextBlink < millis()){
    digitalWrite(pinLED, HIGH);
    delay(250);
    digitalWrite(pinLED, LOW);
    nextBlink = millis() + 500;
  }
}

Done Saving.

8 ATtiny85 (internal 8 MHz clock) on COM6
```

To use at home

- For Windows only (not needed for Mac or Linux):
 - Install usbasp driver -
<http://www.fischl.de/usbasp/>
- Follow directions at:
<http://hlt.media.mit.edu/?p=1695>
- All software from class
 - <https://www.dropbox.com/s/q6209smg70xxrdw/Arduino.zip>