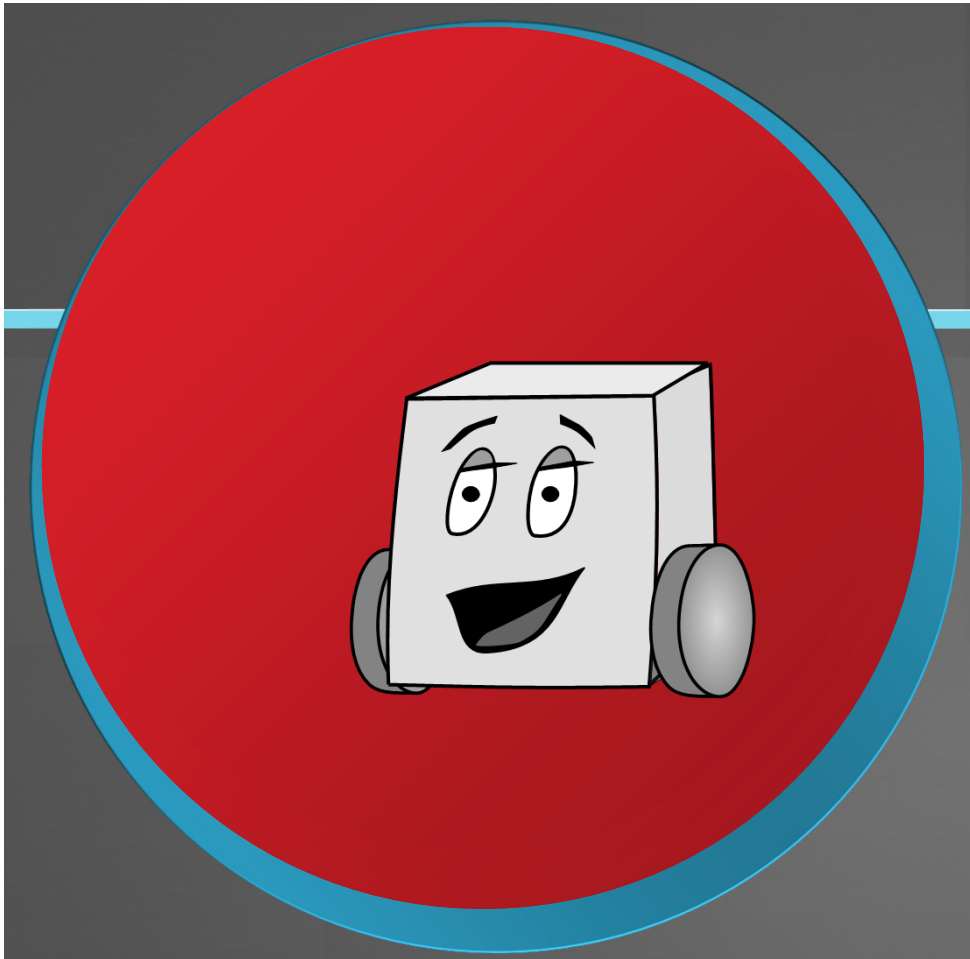

E11 Lecture 4: More C!!!

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Outline

- Operators
- Control Statements
- Arrays
- Function Calls
- Timing

Operators

	Symbol	Operation	Example
Arithmetic	+	addition	y = a + 2;
	-	subtraction	y = a - 2;
	*	multiplication	y = x * 12;
	/	division	z = x / 3;
	%	modulo	z = 5 % 2;
	=	assignment	x = 22;
Comparison	==	equals	(y == 2)
	!=	not equals	(x != 7)
	<	less than	(y < 12)
	>	greater than	(val > max)
	<=	less than or equal	(z <= 2)
	>=	greater than or equal	(y >= 10)
Bool	&&	AND	(x && y)
	||	OR	(x || y)
	!	NOT	!x
Bitwise	&	bitwise AND	y = a & 15;
	|	bitwise OR	y = a | b;
	^	bitwise XOR	y = a ^ b;
	~	bitwise NOT	z = ~x;
	<<	bitshift left	z = 4 << 2;
	>>	bitshift right	x = x >> 8;
Compound	++	increment	a++; // a = a+1
	--	decrement	x--; // x = x -1
	+=	addition and assignment	y += 3; // y = y + 3
	-=	subtraction and assignment	z -= 10; // z = z - 10
	*=	multiplication and assignment	x *= 4; // x = x * 4
	/=	division and assignment	y /= 10; // y = y / 10
	&=	bitwise AND and assignment	y &= 15; // y = y & 15
	|=	bitwise OR and assignment	x |= y; // x = x | y

Operators Example

```
int z, x = 14; int y = 43;  // x = 1110, y = 101011

z = y / x;
z = y % x;
z = x && y;
z = x && 0;
z = x || y;
z = x || 0;
z = x & y;
z = x | y;
z = x ^ y;
z = x << 2;
z = y >> 3;
x += 2;
y &= 15;
```

Operators Example

```
int z, x = 14; int y = 43;  // x = 1110, y = 101011

z = y / x;     // 43/14: z = 3
z = y % x;     // 43 % 14: z = 1
z = x && y;    // Logical AND: z = 1
z = x && 0;    // Logical AND with 0: z = 0
z = x || y;    // Logical OR: z = 1
z = x || 0;    // Logical OR with 0: z = 1
z = x & y;     // Bitwise AND: z = 1010
z = x | y;     // Bitwise OR: z = 101111
z = x ^ y;     // Bitwise XOR: z = 100101
z = x << 2;    // Bitwise leftshift by 2: z =  111000
z = y >> 3;    // Bitwise rightshift by 3: z =  101
x += 2;        // Compound operator: x += 2  = 16
y &= 15;       // Compound operator: y &= 15 = 1011
```

Control Statements

- If

```
if (i == 25)
  Serial.println("You guessed it!");
```

- if / else

```
if (i == 25)
  Serial.println("You guessed it!");
else
  Serial.println("Try again!");
```

switch / case Statement

```
switch (var) {
  case 0:
    ...      // do something
    break;
  case 1:
    ...      // do something else
    break;
  default:
    Serial.println("Invalid entry");
}
```

switch / case Statement

```
switch (var) {
  case 0:
    ... // do something
    break;
  case 1:
    ... // do something else
    break;
  default:
    Serial.println("Invalid!");
}
```

```
if (var == 0) {
    ...     // do something
}
else if (var == 1) {
    ...     // do something else
}
else {
    Serial.println("Invalid!");
}
```

Control Statements

- while

```
int x = 1;
while (x < 1000)
  x = x*2;
```

- do... while

```
int x = 1;
do {
  x = analogRead(0);
} while (x < 300);
```

for Loop

```
int x, i;

for (i = 1; i < 100; i++) {
  i = i * 2;
  Serial.println(i);
}
```

Arrays

- Collection of similar items
- Example syntax:

```
int array[5];      // a 5-element array from index 0 – 4
```

Arrays: Example 1

```
// store the powers of 2 from 0-9 in an array
int powof2[10];

void setup() {
  unsigned int i, x = 1;

  Serial.begin(9600);

  for (i = 0; i < 10; i++) {
    array[i] = x;
    x = x * 2;
    Serial.println(x);
  }
}

void loop()
{
}
```

Your turn!

Write code that sums all of the elements of a 100-entry array called `array1`. (You may assume array1 has been initialized.)

```
int array1[100];

...
```

Your turn!

Write code that sums all of the elements of a 100-entry array called `array1`.

```
int array1[100];

...

int i, total = 0;

for (i = 0; i < 200; i++)
    total += array[i];
```

Arrays: Example 2

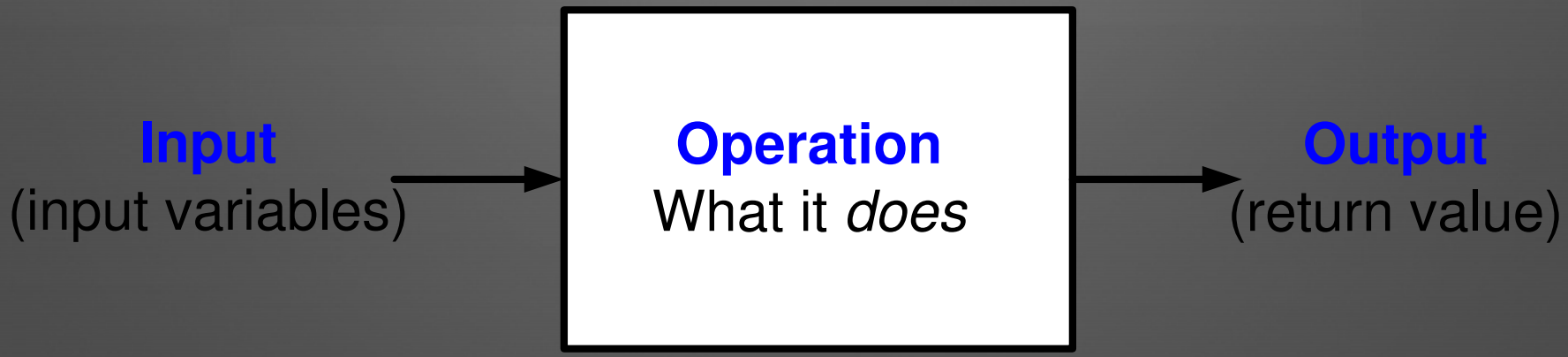
```
// This program initializes an array to random values
// between 0 and 100 and then finds the average value in
// the array.
int randVals[200];

void setup() {

  unsigned int i, average, total = 0;
  Serial.begin(9600);

  for (i = 0; i < 200; i++)
    randVals[i] = random(0,101);

  for (i = 0; i < 200; i++)
    total += randVals[i];

  average = total/200;
  Serial.print("Average value: ");
  Serial.println(average);
}
```

…Now using a function!

```
#define ARRAYSIZE 200
int randVals[ARRAYSIZE];

void setup() {
  unsigned int i;
  Serial.begin(9600);

  for (i = 0; i < ARRAYSIZE; i++)
    randVals[i] = random(0,101);
  getAverage(randVals, ARRAYSIZE);
}

int getAverage(int arr[], int len) {
  int i, average, total = 0;

  for (i = 0; i < len; i++)
    total += arr[i];
  average = total/len;
  Serial.print("Ave: "); Serial.println(average);
  return average;
}
```

Functions

- What is a function?
  - Like a black box
  - A function has:
    - Inputs
    - Outputs
    - Operation



Function Syntax


```
output function_name(inputs)
{
  // operation
}
```

Function Syntax


```
void setup()
{
  // what it does...
}

void loop()
{
  // what it does…
}

int getAverage(int arr[], int len)
{
  // what it does...
}
```

Functions – Example Program

```
int getAverage(int arr[], int len) {
  int i, average, total = 0;

  for (i = 0; i < len; i++)
    total += arr[i];
  average = total/len;
  Serial.print("Ave: "); Serial.println(average);
  return average;
}
```

Your turn!

Write a function "`getMax()`" that returns the maximum of three numbers (that are inputs to the function).

Your turn again!

Write a function "`getMaxArray()`" that returns the maximum value in an array.

Functions – Example Program

```
void setup()
{  int avg;
   int array1[100], array2[100];
   ...

   readSensor(DISTSENSOR, array1, 100);
   avg = getAverage(array1, 100);
   convertToBin(avg, array1, array2, 100);
   printArray(array1, 100);
   printArray(array2, 100);
}
```

Functions – Example Program

```
void readSensor(int pin, int array[], int len) {
    int i;

    for (i=0; i<len; i++)
        array[i] = analogRead(pin - 14);
}

void convertToBin(int avg, int array[],
                  int arrayBin[], int len)
{
    int i;

    for (i=0; i<len; i++)
      if (array[i] < avg) arrayBin[i] = 0;
      else                arrayBin[i] = 1;
}
```

Functions – Example Program

```
int getAverage(int arr[], int len) {
  int i, average, total = 0;

  for (i = 0; i < len; i++)
    total += arr[i];
  average = total/len;
  Serial.print("Ave: "); Serial.println(average);
  return average;
}

void printArray(int array[], int len)
{
  int i;
  for (i=0; i<len; i++) {
    Serial.print(array[i]);
    Serial.print(" ");
  }
  Serial.println("");
}
```

Timing

- delay(time)
  - delays for time ms until continuing execution
- delayMicroseconds(time)
  - delays for time us until continuing execution
- millis()
  - returns time since program started in ms
  - returns unsigned long
- micros()
  - returns time since program started in us
  - returns unsigned long

Using timing for randSeed()

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

  // prompt user
  Serial.println("Press any key to begin");
  while (Serial.available() == 0) ;  // wait for key press
  Serial.read();

  // get time from start of program to user key press (in ms)
  startTime = millis();
  Serial.print("startTime is: "); Serial.println(startTime);
  randomSeed(startTime);        // set the random seed
}

void loop() {
  int randNum = random(0, 100);
  Serial.print("Random number: "); Serial.println(randNum);
  delay(300);
}
```

Timing: frequency

```
#define REDLED 13

void setup()
{
  Serial.begin(9600); // set up Serial communication speed
  pinMode(REDLED, OUTPUT);  // red led is output
}

void loop()
{
  Serial.println("Starting loop\n");
  digitalWrite(REDLED, HIGH); // turn red LED on
  delay(1000);
  digitalWrite(REDLED, LOW);  // turn red LED off
  delay(1000);
}
```

Timing: frequency

```
#define REDLED 13

void setup()
{
  Serial.begin(9600); // set up Serial communication speed
  pinMode(REDLED, OUTPUT);  // red led is output
}

void loop()
{
  Serial.println("Starting loop\n");
  digitalWrite(REDLED, HIGH); // turn red LED on
  delay(1000);
  digitalWrite(REDLED, LOW);  // turn red LED off
  delay(1000);
}
```

But how long does printing take?

Timing: measuring time?

```
#define REDLED 13

void loop() {
  unsigned long startTime, endTime;

  startTime = millis();
  Serial.println("Starting loop\n");
  endTime = millis();
  Serial.print("Elapsed time to print:"); Serial.println(endTime-
startTime);

  digitalWrite(REDLED, HIGH); // turn red LED on
  delay(1000);
  digitalWrite(REDLED, LOW);  // turn red LED off
  delay(1000);
}
```

Your turn!

Write code that reads the distance sensor roughly every 250 ms and prints out the reading.

```
#define DISTSENSOR 14
```

Your turn!

Write code that reads the distance sensor roughly every 250 ms and prints out the reading.

```
#define DISTSENSOR 14

void setup() {

 Serial.begin(9600);
 // set up Serial communication speed
 pinMode(DISTSENSOR, INPUT);  // distance sensor as input
}



void loop()
{
  int reading;

  reading = analogRead(DISTSENSOR-14);
  Serial.print("Reading: "); Serial.println(reading);
  delay(250);
}
```

Your turn!

Write code that reads the distance sensor exactly every 250 ms and then prints out the reading.

```
#define DISTSENSOR 14
```

Reading Sensor Data

Write code that reads the distance sensor exactly every 250 ms and then prints out the reading.

```
void readDistData()
{
   unsigned long time;
   int i;

   time = millis(); // time at start of function in ms

   // record distance sensor data
   // sampling time = 250 ms (sampling rate = 4 bits/second)
   for (i=0; i<ARRAYSIZE; i++) {
     // read analog port
     distData[i] = analogRead(DISTSENSOR-14);
     while (millis() < (time + (i+1)*250))
       ; // pause until time to read again
   }
}
```

Even better!

Write code that reads the distance sensor exactly every 250 ms and then prints out the readings.

```
void readDistData(){
   unsigned long time1, time2;
   int i;

   time1 = millis(); // time at start of function in ms

   // record distance sensor data
   // sampling time = 250 ms (sampling rate = 4 bits/second)
   for (i=0; i<ARRAYSIZE; i++) {
     distData[i] = analogRead(DISTSENSOR-14); // read analog port
     while (millis() < (time1 + (i+1)*250))
       ; // pause until time to read again
   }
   time2 = millis()-time1;
   Serial.print("Time to execute loop: "); Serial.println(time2);
}
```