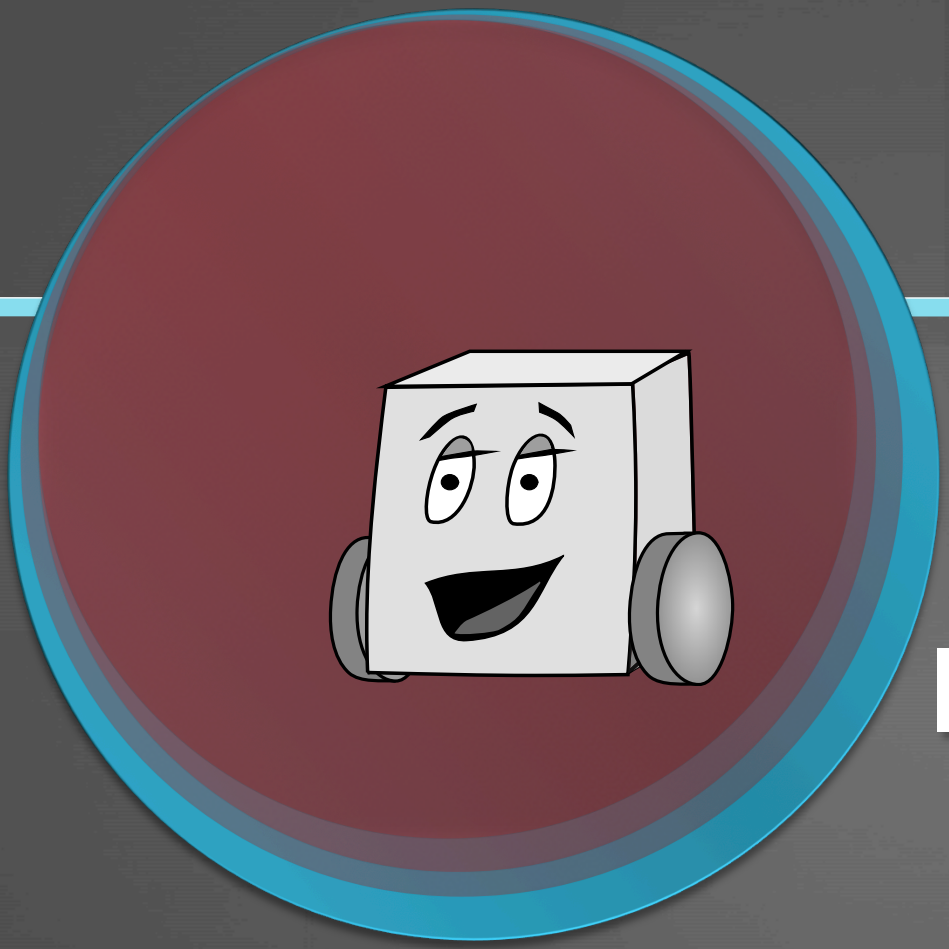

E11 Lecture 2: Introduction to C

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Fall 2014

Outline

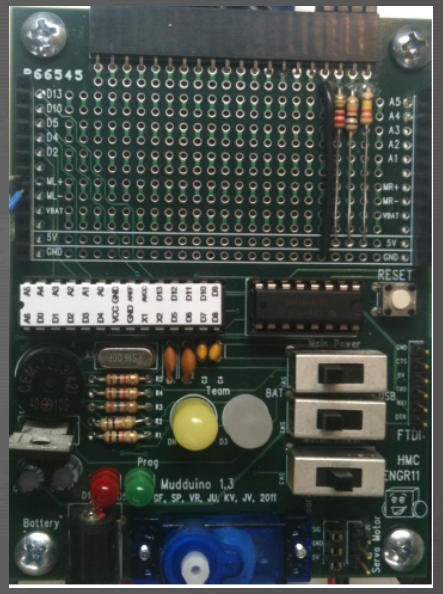
- What is C?
- Programming Target: Arduino
- Programming Basics
  - Simple C Program
  - Running a Program
- Programming Tools
  - Comments
  - Data Types
  - Variables
  - Console Inputs and Outputs
- More stuff you can do…

What is C?

- Created by Dennis Ritchie at Bell Laboratories in 1972
- Programming language for making a computer/ microcontroller do something.
- One of the most popular programming languages:
  - Available for many platforms (supercomputers to embedded microcontrollers)
  - Relatively easy to use, moderate level of abstraction, but programmer also has an idea of how code will be executed
  - Can interact with hardware directly

Programming Target: Arduino

- Arduino
  - type of microcontroller
  - we'll talk about this a lot more next time
- Overall syntax is same as C
- Some differences (we'll highlight them)
- FYI, Arduino's version of C is called "Arduino"



Simple C Program

```
void setup()
{
}

void loop()
{
}
```

This runs first
(sets things up)

Then this runs repeatedly
(it loops)

All programs MUST contain these two functions

Simple C Program: Example

```
void setup()
{
  Serial.begin(9600);
  Serial.println("Hello world!");
}

void loop()
{
}
```

Simple C Program: Example

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

  Serial.println("Hello world!");

}

void loop()
{
}
```

Setup serial port to run at 9600 baud (bits/second)

Print "hello world!" to the serial port (followed by a carriage return)

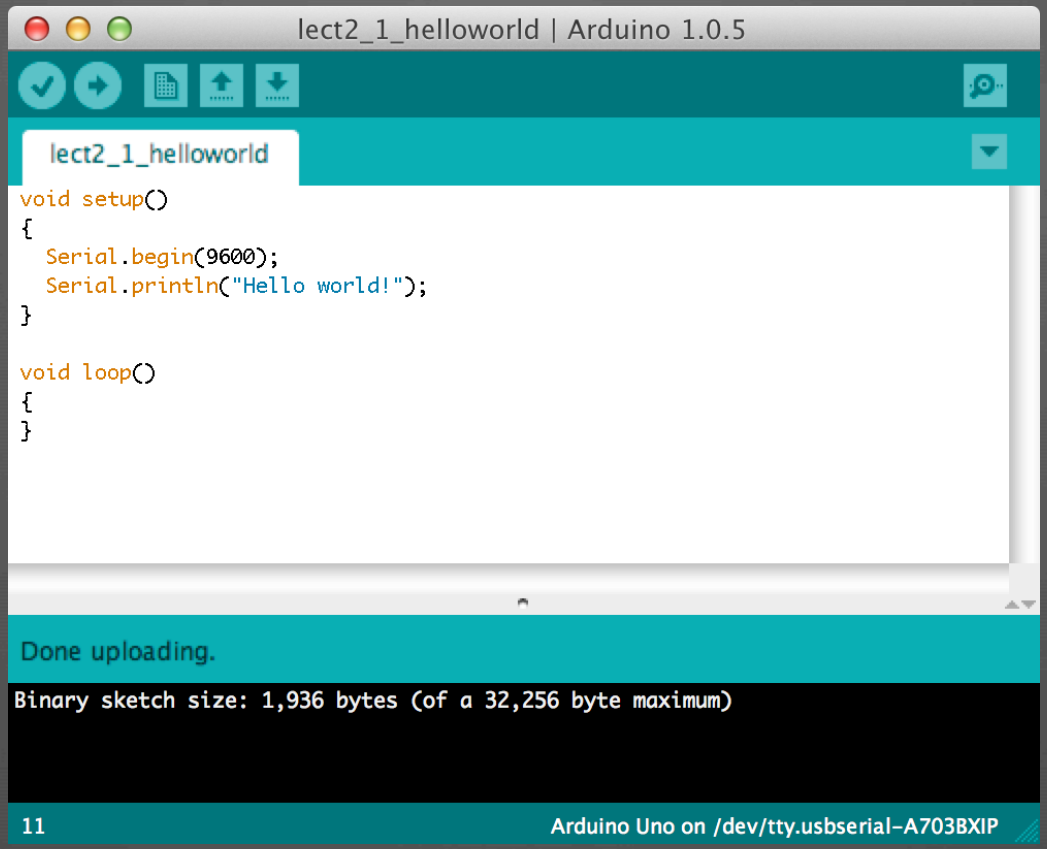
In this program, the loop() function does nothing (but still must be included!)

Running a Program on the Arduino

- Run the Arduino software: *arduino.exe*
  - arduino.cc/en/Main/Software
- Type the program into the *sketch*
- Save the file using a meaningful name – e.g.“helloworld”
  - From the file menu: File -> Save As
  - The file will save with the .ino extension (helloworld.ino)
- Connect the Arduino board using an FTDI USB cable
  - Black wire goes to GND
- Change the settings to the correct device and port
  - From the file menu: Tools -> Board -> Arduino Uno
  - Check the USB port settings with Tools -> Serial Port
    - Random COM port on Windows
    - /dev/tty.usbserial-randomcharacters on mac
- Verify the code
- Upload the code
- Open the Serial Monitor (after the code uploads)

Running a Program on the Arduino (cont.)

- Run the Arduino software: *arduino.exe*
- Type the program into the *sketch*



Demo

Coding: Your Turn!

Write a program that repeatedly prints the phrase: “I love E11 already!”

Coding: Your Turn!

Write a program that repeatedly prints the phrase: "I love E11 already!"

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

void loop()
{
  Serial.println("I love E11 already!");
}
```

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- More stuff you can do…

Comments

- Are ignored by the computer running the program
- But are **critical** for clarity and organization
- Single-line comment

```
// single-line comment
```

- Multiple-line comments

```
/* multiple-line
   comment */
```

Data Types

- A data type tells us:
  - The **type** of values represented
  - The **range** of values

Data Types

Type	Size (bits)	Minimum	Maximum
char	8	-2^7 (-128)	$2^7 - 1$ (127)
unsigned char	8	0	$2^8 - 1$ (255)
int	16	-2^{15} (-32,767)	$2^{15} - 1$ (32,768)
unsigned int	16	0	$2^{16} - 1$ (65,535)
long	32	-2^{31} (-2,147,483,648)	$2^{31} - 1$ (2,147,483,647)
unsigned long	32	0	$2^{32} - 1$ (4,294,967,295)
float	32	$\pm 2^{-126}$	$\pm 2^{128} * (2-2^{-15})$
boolean	8	false	true

Note: byte = unsigned char
double = float
word = unsigned int

Binary Numbers: Range

- What happens when a result won't fit in that range?
  - Overflow!
  - For example, with only 2 bits:

    11 + 01 = 100 = 00!

Overflow Example

```
void setup()
{
  char x = 33;
  char y = 257;
  Serial.begin(9600);

  Serial.print("The value of x is ");
  Serial.println(x, DEC);

  Serial.print("The value of y is ");
  Serial.println(y, DEC);
}

void loop()
{
}
```

Variables

- Each variable has a:
  - Name
  - Type
  - Value

Example:

```
int cnt = 5;  // name is cnt, type is int, value is 5
```

Variables

```
int count = 0;  // global variable

void setup() {
   char x;          // local variables
   float y = 7.8;
   boolean found = false;

   x = 12;          /* x is initialized
                       after it is
                       declared. */

   ...
}
```

Variables

- All variables must be *initialized* (set to a known value) before they are used
- Global variables:
  - are declared outside of all functions
  - are accessible anywhere in the program
- Local variables
  - are declared within a function
  - are only accessible within that function

Variables

```
int cnt = 0;

void setup() {
  char x;
  float y = 7.8;
  boolean found = false;

  x = 12;
  ...
}

void loop()
{
  cnt = 42;
  x = 3;
}
```

Coding: Your Turn!

Write a program that converts the variable x from centimeters to inches and prints the value of x in both units.

```
// convert x from cm to in
int x = 12;
```

Coding: Your Turn!

Write a program that converts the variable x from centimeters to inches and prints the value of x in both units.

```
// convert x from cm to in
int x = 12;
float y = 12/2.54;

Serial.print("x = "); Serial.print(x);
Serial.print(" cm = "); Serial.print(y);
Serial.println(" inches.");
```

Console Input and Output

- Output
  - Serial.print(*string or variable name*);
  - Serial.println(*string or variable name*);
- Input
  - int Serial.read();

Console Input and Output Example

```
void setup()
{
  Serial.begin(9600); // opens serial port at 9600 baud
  Serial.println("Enter a value: ");
}

void loop() {
  int incomingByte = 0; // incoming serial data

  // read user input
  if (Serial.available() > 0) {
    incomingByte = Serial.read();

    // print result:
    Serial.print("I received: ");
    Serial.println(incomingByte, HEX);
  }
}
```

ASCII

Binary	Octal	Decimal	Hexadecimal	Glyph
010 0000	040	32	20	space
010 0001	041	33	21	!
010 0010	042	34	22	"
010 0011	043	35	23	#
010 0100	044	36	24	$
010 0101	045	37	25	%
010 0110	046	38	26	&
010 0111	047	39	27	'
010 1000	050	40	28	(
010 1001	051	41	29	)
010 1010	052	42	2A	*
010 1011	053	43	2B	+
010 1100	054	44	2C	,
010 1101	055	45	2D	-
010 1110	056	46	2E	.
010 1111	057	47	2F	/
011 0000	060	48	30	0
011 0001	061	49	31	1
011 0010	062	50	32	2
011 0011	063	51	33	3
011 0100	064	52	34	4
011 0101	065	53	35	5
011 0110	066	54	36	6
011 0111	067	55	37	7
011 1000	070	56	38	8
011 1001	071	57	39	9
011 1010	072	58	3A	:
011 1011	073	59	3B	;
011 1100	074	60	3C	<
011 1101	075	61	3D	=
011 1110	076	62	3E	>
011 1111	077	63	3F	?

Binary	Octal	Decimal	Hexadecimal	Glyph
100 0000	100	64	40	@
100 0001	101	65	41	A
100 0010	102	66	42	B
100 0011	103	67	43	C
100 0100	104	68	44	D
100 0101	105	69	45	E
100 0110	106	70	46	F
100 0111	107	71	47	G
100 1000	110	72	48	H
100 1001	111	73	49	I
100 1010	112	74	4A	J
100 1011	113	75	4B	K
100 1100	114	76	4C	L
100 1101	115	77	4D	M
100 1110	116	78	4E	N
100 1111	117	79	4F	O
101 0000	120	80	50	P
101 0001	121	81	51	Q
101 0010	122	82	52	R
101 0011	123	83	53	S
101 0100	124	84	54	T
101 0101	125	85	55	U
101 0110	126	86	56	V
101 0111	127	87	57	W
101 1000	130	88	58	X
101 1001	131	89	59	Y
101 1010	132	90	5A	Z
101 1011	133	91	5B	[
101 1100	134	92	5C	\
101 1101	135	93	5D	]
101 1110	136	94	5E	^
101 1111	137	95	5F	_

Binary	Octal	Decimal	Hexadecimal	Glyph
110 0000	140	96	60	`
110 0001	141	97	61	a
110 0010	142	98	62	b
110 0011	143	99	63	c
110 0100	144	100	64	d
110 0101	145	101	65	e
110 0110	146	102	66	f
110 0111	147	103	67	g
110 1000	150	104	68	h
110 1001	151	105	69	i
110 1010	152	106	6A	j
110 1011	153	107	6B	k
110 1100	154	108	6C	l
110 1101	155	109	6D	m
110 1110	156	110	6E	n
110 1111	157	111	6F	o
111 0000	160	112	70	p
111 0001	161	113	71	q
111 0010	162	114	72	r
111 0011	163	115	73	s
111 0100	164	116	74	t
111 0101	165	117	75	u
111 0110	166	118	76	v
111 0111	167	119	77	w
111 1000	170	120	78	x
111 1001	171	121	79	y
111 1010	172	122	7A	z
111 1011	173	123	7B	{
111 1100	174	124	7C	|
111 1101	175	125	7D	}
111 1110	176	126	7E	~

In my eyes, that should be spelled ASCIII

Console Input and Output Example

```
int incomingByte = 0; // incoming serial data

void setup()
{
  Serial.begin(9600); // opens serial port at 9600 baud
  Serial.println("Enter a value: ");
}

void loop() {
  // read user input
  if (Serial.available() > 0) {
    incomingByte = Serial.read();

    // print result:
    Serial.print("I received: ");
    Serial.println(incomingByte, DEC);
  }
}
```

Print Formats

- Print formats

  Serial.print(*val*, *format*)

  Serial.println(*val*, *format*)

  – *val* is value to print (any data type)

  – *format* is:

    – DEC (decimal)
    – HEX (hexadecimal)
    – OCT (octal)
    – BIN (binary)
    – BYTE (ASCII-interpreted byte)
    – or number of decimal places (for floating point)

Physical Inputs and Outputs

- **Setup:**
  - pinMode(*pin*, *mode*)
  - *mode* is either: INPUT or OUTPUT
- **Output – setting a pin value:**
  - digitalWrite(*pin*, *value*)
  - *value* is either: HIGH or LOW
- **Input:**
  - digitalRead(*pin*)

Physical Output: LED

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

  // set LED pin as output
  pinMode(13, OUTPUT); // LED pin
}

void loop()
{
  Serial.println("Testing LED");

  digitalWrite(13, HIGH); // turn the LED on
  delay(200);             // delay 200 ms

  digitalWrite(13, LOW);  // turn the LED off
  delay(200);             // delay 200 ms
}
```

Physical Output: Speaker

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

  // set speaker pin and LED as outputs
  pinMode(4, OUTPUT);  // speaker pin
  pinMode(13, OUTPUT); // LED pin
}
void loop()
{
  Serial.println("Testing speaker");

  tone(4, 440);            // write tone of 440 Hz to speaker
  digitalWrite(13, HIGH); // turn the LED on
  delay(200);              // delay 200 ms
  noTone(4);               // turn the speaker (pin 4) off
  digitalWrite(13, LOW);  // turn the LED off
  delay(200);              // delay 200 ms
}
```

Useful Resource!!!

http://arduino.cc/en/Reference/HomePage