Introduction to Haptics

Arduino Programming Language

(optional material for beginning programmers)

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Programming Guidance

Potential resources:

- Online courses (e.g., EdX, Udacity)
- Web tutorials (Java or C programming languages are most appropriate)
- Arduino-specific tutorials

In this class:

- You will start from existing programs (sketches) and modify them
- The complexity of the programming you will do is low
- Debugging can be difficult because of the real-time nature of haptic interaction
- You should learn by doing. There is little you can do to damage your Hapkit through programming mistakes!

We will start by going through some examples at

http://www.learn-c.org/

Arduino Programming Language Components

Structure

- Basic syntax
- Arithmetic operators
- Control structures
- Comparison Operators
- Boolean Operators

Variables

- Constants
- Data types
- Scope

Functions

- Digital I/O
- Analog I/O
- Math
- Serial communication
- Defining your own

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Structure: Basic Syntax

`;` Each statement ends in a semicolon. For example: `int a = 13;`

`{ }` Curly braces always come in pairs; they are used to define the start and end of functions, loops, and conditional statements. For example:

```
while (boolean expression)
  {
     statement(s)
  }
```

`//` Single line comment

`/*  */` Multi-line comment

`#define` Used to give a name to a constant value. For example: `#define ledPin 3`

Structure: Arithmetic operators

`=` Assignment operator stores the value to the right of the equal sign in the variable to the left of the equal sign: `sensorVal = analogRead(FSRPin);`

`+` `-` `*` `/` Addition, subtraction, multiplication, and division. For example:

```
    result = value1 + value2;
    result = value1 - value2;
    result = value1 * value2;
    result = value1 / value2;
```

where `value1` and `value2` are any variables or constants

Tips:

- Choose variable sizes that are large enough to hold the largest calculated result
- For math that requires fractions, use float variables (but there are drawbacks)
- Check for order of operations; use parentheses to enforce order

Structure: Control structures

`if` Tests whether a certain condition has been reached. Used in conjunction with a comparison operator. For example:

```
if (someVariable > 50)
{
  // do something here
}
```

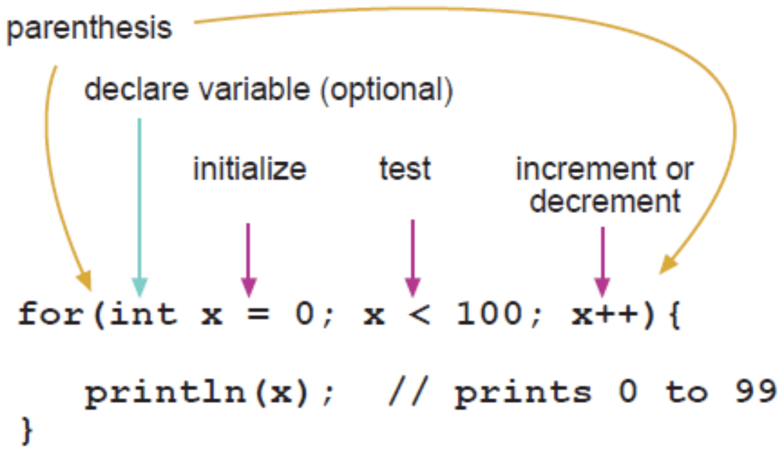
`if...else` Allows you to do multiple tests. For example:

```
if (force > 1)
{
  // action A
}
else
{
  // action B
}
```

Structure: Control structures

`for` Creates a loop for repetitive operations.

```
for (initialization; condition;  increment) {
  //statement(s);
}
```



```
for(int x = 0; x < 100; x++){
   println(x);  // prints 0 to 99
}
```

Structure: Control structures

`switch case` Allows you to specify different code that should be executed in various conditions. For example:

```
switch (var) {
  case 1:
    //do something when var equals 1
    break;
  case 2:
    //do something when var equals 2
    break;
  default:
    // if nothing else matches, do the default
    // default is optional
}
```

Structure: Comparison Operators

The result of a statement with a comparison operator is either TRUE (1) or FALSE (2)

```
x == y (x is equal to y)
x != y (x is not equal to y)
x <  y (x is less than y)
x >  y (x is greater than y)
x <= y (x is less than or equal to y)
x >= y (x is greater than or equal to y)
```

Tips:

- Be careful not to accidentally use the assignment operator = instead of ==.
- Cannot use statements such as `0 < x < 1`; need to do each comparison separately

Arduino reference materials obtained from http://arduino.cc under a *Commons Attribution-ShareAlike 3.0 License*.

Structure: Boolean Operators

`&&` Logical AND. True only if both operands are true, e.g.

```
if (digitalRead(2) == HIGH  && digitalRead(3) == HIGH) {
  // do this only if both inputs are high
}
```

`||` Logical OR. True if either operand is true, e.g.

```
if (x > 0 || y > 0) {
  // do this if either x or y is greater than 0
}
```

`!` NOT. True if the operand is false, e.g.

```
if (!x) {
  // do this if x is false (0)
}
```

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Variables: Constants

`HIGH`
`LOW`

When reading or writing to a digital pin, there are only two possible values a pin can take (or be set to): HIGH and LOW

`true`
`false`

Logical levels (result of a comparison):
false is defined as 0
true is defined as 1 (but more broadly, anything but 0)

In addition, integer and floating-point constants can be used:

Decimal integers

```
2
101
3200
```

Floating point

```
10.0
2.34E5
67e-12
```

Variables: Data types

`void` Used in function delcarations to indicate that the function returns no information. For example:

```
void setup()
{
  // ...
}
```

```
void loop()
{
  // ...
}
```

`boolean` A boolean holds one of two values, true or false. For example:

```
boolean running = false;
if (running) {
// do something
}
```

Variables: Data types

`char` A data type that stores a character value. For example:

```
char myChar = 'A';
char myChar = 65;     // both are equivalent
```

Coding is in this ASCII chart: http://arduino.cc/en/Reference/ASCIIchart

`float` Datatype for floating-point numbers, a number that has a decimal point.

`double` Floating-point numbers are often used to approximate analog and continuous values because they have greater resolution than integers. Floats have 6-7 decimal digits of precision. On the Hapkit board, `double` is the same as `float`.

Variables: Scope

Global vs. Local:

- A **global** variable is one that can be seen by every function in a program. Define it outside a function.
- A **local** variable is only visible to the function in which it is declared. Define it inside a function.
- For complex programs, local variables can help prevent programming errors. However, global variables are an easy way to share information across functions.

The **static** keyword is used to create variables that are visible to only one function. However unlike local variables that get created and destroyed every time a function is called, static variables persist beyond the function call, preserving their data between function calls. For example: `static int a;`

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Functions: Digital I/O

For a description of the roles of different pins on the Arduino/Hapkit, see
http://arduino.cc/en/Tutorial/DigitalPins

`pinMode(pin, mode)` Configures the specified pin to behave either as an input or an output. `pin` is the pin number.

`digitalWrite(pin, value)` Write a `HIGH` or a `LOW` value to a digital pin.

`digitalRead(pin)` Reads the value from a specified digital pin. The result will be either HIGH or LOW.

Functions: Analog I/O

`analogReference(type)` The default reference voltage is 5V. This can be changed to a different `type` and different resolution using this function.

`analogRead(pin)` Reads the value from the specified analog pin and returns a value between 0 and 1023 to represent a voltage between 0 and 5 volts (for default). It takes about 0.0001 seconds to read an analog pin.

`analogWrite(pin,value)` Writes an analog value (PWM wave) to a pin. `value` is the duty cycle: between 0 (always off) and 255 (always on). Works on pins 3, 5, 6, 9, 10, and 11.

Functions: Math

`min(x, y)` Calculates the minimum of two numbers

`max(x, y)` Calculates the maximum of two numbers

`abs(x)` Computes the absolute value of a number

`pow(base, exponent)` Calculates the value of a number raised to a power

`sqrt(x)` Calculates the square root of a number

`map(value, fromLow, fromHigh, toLow, toHigh)` Re-maps a number from one range to another. That is, a value of `fromLow` would get mapped to `toLow`, a value of `fromHigh` to `toHigh`, values in between to values in between.

Trigonometric functions such as `sin`, `cos`, and `tan` are also available.

Functions: Serial communication

Typically used for communication between an Arduino board and a computer via the USB port. Use the **serial monitor** to communicate with the board.

`Serial.begin(9600);` Used to begin serial communications, typically at a 9600 baud rate (bits per second)

`Serial.print(val,format);` Prints data to the serial port as human-readable ASCII text. Examples:

```
Serial.print(78) gives "78"
Serial.print(1.23456) gives "1.23"
Serial.println(1.23456, 4) gives "1.2346"
Serial.print("Hello world.") gives "Hello world."
```

`Serial.println(val);` Prints `val` followed by carriage return

Functions: Defining your own

Many other functions have been created by Arduino users; some are posted at http://playground.arduino.cc/Main/GeneralCodeLibrary

You can also define your own function.
This could be used to make your code more organized and efficient.

```
int find_text(String needle, String haystack) {
  int foundpos = -1;
  for (int i = 0; (i < haystack.length() - needle.length()); i++) {
    if (haystack.substring(i,needle.length()+i) == needle) {
      foundpos = i;
    }
  }
  return foundpos;
}
```

This is a function that searches for a given string within another string. If the search string is found its position is returned, otherwise -1 is returned.