E11 Lecture 8: C – never enough!

Prof. David Money Harris
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Outline

- Multi-dimensional arrays
- Testing the limits
- Programming Practice
- Nuts and bolts
  - Multiple files
  - other C files
  - #include
- Other useful functions
Multi-dimensional Arrays

```c
int grades[10][8];
```
int grades[10][8];

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</table>
Multi-dimensional Arrays

```c
int grades[10][8];

// initialize all entries in array to 0
int i, j;

for (i=0; i<10; i++)
    for (j=0; j<8; j++)
        grades[i][j] = 0;
```
Multi-dimensional Arrays

// initialize array at declaration
int grades[10][8] =
    { {100, 107, 99, 101, 100, 104, 109, 117},
      {103, 101, 94, 101, 102, 106, 105, 110},
      {101, 102, 92, 101, 100, 107, 109, 110},
      {114, 106, 95, 101, 100, 102, 102, 100},
      {98, 105, 97, 101, 103, 104, 109, 109},
      {105, 103, 99, 101, 105, 104, 101, 105},
      {103, 101, 100, 101, 108, 105, 109, 100},
      {100, 102, 102, 101, 102, 101, 105, 102},
      {102, 106, 110, 101, 100, 102, 120, 103},
      {99, 107, 98, 101, 109, 104, 110, 108} };
Multi-dimensional Arrays

// get the mean for a problem set and overall
for (i=0; i<8; i++) {  // for each of the 8 problem sets
    total_tmp = 0;
    for (j=0; j<10; j++) {
        total_tmp += grades[j][i];  // calculate sum of scores
    }
    mean_ps[i] = total_tmp/10;  // calculate p.s. mean
    Serial.print("Problem Set "); Serial.print(i+1);
    Serial.print(":"); Serial.println(mean_ps[i]);
    mean_overall += total_tmp;  // sum all the scores
}
mean_overall = mean_overall/(10*8);  // calculate overall mean
Serial.print("Overall mean:"); Serial.println(mean_overall);
Testing the Limits

- **Atmega328**
  - Program memory: 32 KB of Flash Memory (retains value when powered off)
  - Data memory: 2 KB of static random access memory (SRAM) (loses value when powered off)
Data memory: 2 KB

- How big of an int array can I declare?
  - 2048 Bytes/(2 Bytes/element) = 1024-element array
  - But also other data (bootloader, Serial library data, etc.) – so can’t use entire 2 KB.
How big of an int array can I declare?

- 2048 Bytes/(2 Bytes/element) = 1024-element array

```c
// datalimit.pde  - 19 September 2011
// Sarah Harris - sarah_harris@hmc.edu
// testing limits on data

#define SIZE 800  // vary array size to see what happens

int array[SIZE];

void setup() {  
  int i;

  Serial.begin(9600);  Serial.println("Starting program...");

  for (i = 0; i < SIZE; i++) {
    array[i] = random(0,101);
    Serial.println(array[i]);  // 10
  }
```
How big of an int array can I declare?

- 2048 Bytes/(2 Bytes/element) = 1024-element array

```cpp
// datalimit.pde  -  19 September 2011
// Sarah Harris - sarah_harris@hmc.edu
// testing limits on data

#define SIZE 900

int array[SIZE];  // with size of 900, program starts behaving randomly

void setup() {
    int i;

    Serial.begin(9600);  Serial.println("Starting program...");

    for (i = 0; i < SIZE; i++) {
        array[i] = random(0,101);
        Serial.println(array[i]);
    }
}```
How big of an int array can I declare?

- 2048 Bytes/(2 Bytes/element) = 1024-element array

// datalimit.pde - 19 September 2011
// Sarah Harris - sarah_harris@hmc.edu
// testing limits on data

#define SIZE 1000

int array[SIZE]; // at 1000, program acts as if uploads but doesn't

void setup() {
  int i;

  Serial.begin(9600); Serial.println("Starting program...");

  for (i = 0; i < SIZE; i++) {
    array[i] = random(0,101);
    Serial.println(array[i]);
  }
}
How big can program be?

- Many instructions – can look at size when compiling or uploading
- Some of it used by bootloader (1/2 KB)
- Some used by libraries (like Serial library)
Outline

- Timing
- Multi-dimensional arrays
- Testing the limits
- Programming Practice
- Nuts and bolts
  - Multiple files
  - other C files
  - #include
- Other useful functions
How do you approach writing a program?
How do you approach writing a program?

Before you sit in front of a computer:
- Write down the steps of the program (in English)
  - Start with major steps, then break them down into smaller steps

Work on one step at a time
- Write code (using functions – modularity!)
- Test that small piece of code thoroughly
- Then move on to the next step
Nuts and Bolts: Multiple Files

- Enables:
  - organization
  - code reuse
Multiple Files in a Single Sketch

- For example, you may have a group of functions that you consistently use.

- By adding the `.pde` file to the sketch, you can use any of the functions.

- Be sure you only have extra functions in your added `.pde` – not `setup()` or `loop()`. 
Multiple Files in a Single Sketch

// otherfunctions.pde
void printArray(int array[], int length)
{
  
...
}

int getKeyPress()
{
  
...
}
Multiple Files in a Single Sketch

- How to do this – two ways:
  1. Place extra .pde file in the sketch folder. (Now it will show up as a tab in the sketch, and you can use the functions.)
Multiple Files in a Single Sketch

- How to do this – two ways:
  2. Add a tab yourself manually and type in the functions in that tab.
Multiple Files in a Single Sketch

- Remove the file from the sketch by simply removing it from the sketch folder.
Multiple Files in a Single Sketch

- Or you may have some #defines that you consistently use.
Multiple Files in a Single Sketch

Or you may have some #defines that you consistently use.

1. Add new tab
2. Name it with a “.h” extension. For example, pins.h
3. Place this line in .pde file: #include “pins.h”
Some other useful functions

- **abs(var)** – returns the absolute value of var
  - **Example:**
    ```
    int y = -20;
    int x = abs(y); // x = 20
    ```

- **min(x, y)** – returns the minimum of x or y
  - **Example:**
    ```
    int x = 4;
    int y = 2;
    int minimum = min(x, y); // minimum = 2
    ```

- **casting characters:** char(x), int(x), long(x), float(x)
  - **Casts x to the corresponding type**
  - **Example:**
    ```
    char x = 2;    // x is a 1-byte data type: 00000010
    int y = int(x); // y is a 2-byte data type: 00000000 00000010
    ```