CS 161
Introduction to CS I
Lecture 18

- Creating dynamic arrays
- Passing arrays to functions

Week 7 tips

- Study worksheet 7 is posted – give it a try after this lecture
- Assignment 4
  - Use valgrind to check for memory leaks (and other issues)
  - C-style strings: allocate enough room for the null character
    - strlen() does not include this character
  - Use the stack for local variables that will not grow/shrink.
    Use the heap for memory you need to pass around or change size over time.

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Week 7 tips (2)

- Midterm 2 coming up on 2/28 – LINC 100
  - Covers material through end of week 7 (**cumulative**)
  - Practice questions will be posted by Monday 2/24 (week 8)
  - In-class review (but that's not all) on 2/26
  - Evening review session on 2/27, 6-7 p.m. in LINC 228

Static and dynamic memory

- Stack: memory is permanently allocated (within function) and permanently gone (when function exits)
  - "Gone" means that memory can be re-used
    (so no guarantee it will contain the original data)
- Heap:
  - Memory can be allocated when needed, freed when not needed
    - (e.g., each web page served; each document edited in a word processor)
  - Memory consumption can dynamically grow and shrink
    - Within a function
    - In different functions

A note about pointer arithmetic

- Increment a pointer in memory (e.g., to next item in an array):
  - `p++;`
  - `p += 2;`
  - These statements change where the pointer is pointing
- Increment **the value** the pointer points to:
  - `(*p)++;`
  - `(*p) += 2; /* () not required here, but a good idea */`
  - These statements do not change where the pointer is pointing

Review static 1D arrays

```
1. const int n_people = 5;
2. int height[n_people];
3. for (int i=0; i<n_people; i++)
4.    height[i] = rand()%13 + 60;
```

- Note: allocating based on user input works too:

```
1. int n_people; cin >> n_people;
2. int height[n_people];
3. for (int i=0; i<n_people; i++)
4.    height[i] = rand()%13 + 60;
```

See lec18-static-array.cpp

- But it cannot be changed later (different **n_people**)

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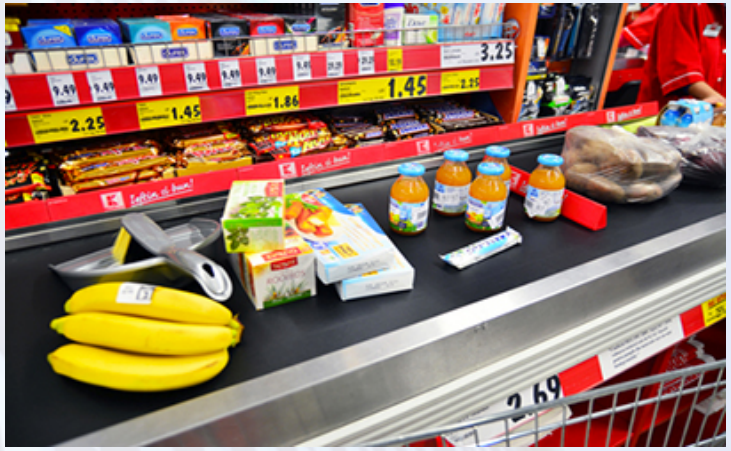
Review C-style strings

- C-style string: char array with '\0' (null) terminator
- Your turn: If the user types "Fred", what will this output?

```
1. char name[5] = {};
2. cin.getline(name, 5); /* 5 includes '\0' */
3. cout << name[0];
4. for (int i=1; i<strlen(name); i++) {
5.   cout << "_" << name[i];
6. }
7. cout << endl;
```

Why do we need a null terminator?

- The \0 (null) character indicates where the string ends in memory, just like the red bar on the grocery conveyer belt:
- If you omit it, many functions will not know when to stop
  - strlen(): when to stop counting?
  - cout: when to stop printing?
- You may get lucky if the memory after your array happens to be 0, but no guarantees



- valgrind will give an error for `strlen()`:
  - "Conditional jump or move depends on uninitialised value(s)"

C++ vs. C-Style strings

- What to #include
  - C++: `<string>`
  - C-style: `<cstring>` (C++ version of C's `<string.h>`)
- Declaration
  - C++: `string`
  - C-style: `char[]`
- Access
  - `s.at(i)` or `s[i]`
  - `s[i]`
- Compatibility
  - C-style to C++: automatically converted
  - C++ to C-style: use `s.c_str()` to get a C-style string (`char*`) from `s`

Passing arrays to functions

- Arrays are always passed by reference (not value)
  - Why?
  - What does this mean for us?

```
1. int grades[5] = {90, 80, 85, 95, 100};
2. int max_grade = get_max(grades, 5); /* pass by ref */
```

- Assuming a function defined as one of the following:

```
1. int get_max(const int g[], const int n);
2. int get_max(const int* g,  const int n);
```

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Passing arrays to functions

```
1. int get_max(const int* g, const int n) {
2.   int m = g[0];
3.   for (int i=1; i<n; i++) {
4.     if (g[i] > m)
5.       m = g[i];
6.   }
7.   return m;
8. }
```

See lec18-pass-array.cpp

```
1. int main() {
2.   int grades[] = {90, 80, 85, 95, 100};
3.   cout << get_max(grades, 5) << endl;
4.   return 0;
5. }
```

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Dynamic arrays (on the heap)

- Dynamic single item

```
1. float* f = new float;
2. . . .
3. delete f;
4. f = NULL;
```

- Dynamic array (e.g., when size could change)

```
1. float* g = new float[3];  /* from heap */
2. . . .
3. delete [] g; /* free the memory */
4. g = NULL;
```

Dynamic arrays

- Allow us to allocate and release memory as needed
- Web server: Instead of storing all possible web pages forever, only allocate space when it is served and release when that page is no longer in use

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Stack and heap arrays

- Given these declarations:

```
1. int stack_arr[5];
2. int* heap_arr;
```

- Let's write code to:
  1. Allocate 5 integers from the heap for heap_arr
  2. For each array (stack_arr, heap_arr):
     a. Set the item at index 2 to 42
     b. Print the item at index 2
     c. Increment the item at index 2
     d. Print the address of the first item
  3. Free the memory associated with heap_arr

See lec18-arrays.cpp

What ideas and skills did we learn today?

- The importance of the null terminator for C-style strings
- How to pass arrays to functions
- Why it is useful to declare a function parameter "const"
- How to declare 1D arrays on the heap
- How delete 1D arrays on the heap

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Week 7 begins!

- ❑ Attend lab (laptop required)
- ❑ Read **Rao Lesson 7** (pp. 165-166)
  Rao Lesson 8 (pp. 189-198)
  Rao Lesson 4 (pp. 71-74)
  Rao Lesson 6 (pp. 145-146)
- ❑ Study session Thursday 2/20, 6-7 p.m. in LINC 268
- ❑ **Assignment 4 Peer Review** (due **Wednesday, Feb. 19**)

See you Wednesday!

- ❑ Bring: [Name of] object you could model as a 2D array