Arrays and Strings

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Arrays and Pointers

- In C, array names are just aliases that can be used as pointers
  
  ```c
  int y[] = {2, 3, 4, 5};  // these two are
  int *y = {2, 3, 4, 5};   // roughly equivalent
  ```

- Indexing and dereferencing pointers are equivalent
  
  Side note: you can do arithmetic with pointers!

  ```c
  *y ≡ y[0]    *(y+1) ≡ y[1]
  ```
Arrays and Pointers

- Pointer types are important!
  - If $x$ is an `int8_t*`, $x[3]$ accesses element at byte offset $3 \times 1 = 3$
  - If $y$ is an `int32_t*`, $y[3]$ accesses element at byte offset $3 \times 4 = 12$
int x = 1;
int y[4] = {2, 3, 4, 5};
int *p = &x;
*p = 6;
p = y;
*p = 7;

What are the values of x and y at the end?
int x = 1;
int y[4] = {2, 3, 4, 5};
int *p = &x;
*p = 6;
p = y;
*p = 7;
Pointers

```c
int x = 1;
int y[4] = {2, 3, 4, 5};
int *p = &x;
*p = 6;
p = y;
*p = 7;
```
int x = 1;
int y[4] = {2, 3, 4, 5};
int *p = &x;
*p = 6;
p = y;
*p = 7;
int x = 1;
int y[4] = {2, 3, 4, 5};
int *p = &x;
*p = 6;
p = y;
*p = 7;
int x = 1;
int y[4] = {2, 3, 4, 5};
int *p = &x;
*p = 6;
p = y;
*p = 7;
int x = 1;
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int *p = &x;
*p = 6;
p = y;
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Pointers

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int x = 1;
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int *p = &x;
*p = 6;
p = y;
*p = 7;
```

What about this?

```c
p++;
*p = 9;
```
Arrays and Pointers

- The same is (roughly) true for C "strings" (arrays of chars)
  
  ```
  char  text[]  =  "hello";  // read-write
  char  *text   =  "hello";  // read-only
  ```

- Diagram showing the memory allocation for the string "hello".
C Strings

- C strings are a sequence of ASCII chars **terminated with null char** (‘\0’)
  - Declare and initialize (static/stack, no explicit size needed):
    - char *name = "John Smith";
    - char name[] = "John Smith";
  - Declare only (static/stack, size needed):
    - char name[11];
  - Declare only (heap, size needed):
    - char *name = (char*) malloc (sizeof(char) * 11);

- Useful functions (need to **#include <string.h>**)
  - Find length: strlen
  - Copy string or convert / format data into string: snprintf
  - Convert to long / float: strtol/strtod
  - Compare strings: strncmp
  - Search for substring: strstr
### ASCII TABLE

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Copying strings

• In Java: `dest = str1 + str2;  // copy strings`
  – What does this code do in C?

• Need to copy all characters from one string to another
  – First for `str1` and then for `str2`
Copying strings

- Old solution: `strcpy`  
  - Basically: `void strcpy (char *dest, char *src)`
    ```c
    {  
      for (int i = 0; src[i] != '\0'; i++) {
        dest[i] = src[i];
      }
    }
    ```

- What happens if `src` isn't null-terminated?

OUT OF BOUNDS!!!
Copying strings

• Using `strcpy` is now considered **unsafe**
  – You are **not permitted** to use it in CS 261
• Solution: specify a maximum length that is safe to copy
  – This is usually the allocated length of the destination
• Older alternative: `strncpy`
  – Requires a maximum length
  – However, it does not guarantee the result is null-terminated
• Newer alternative: `strcpy_s`
  – However, it is not in the C99 standard
• **Better alternative:** `snprintf`
  – Safe, C99-standard, and more powerful than the other two
Output and string conversion

- `printf` and `snprintf` are conceptually similar
  - The former prints to standard out
  - The latter "prints" to a string (character array)
  - The latter can also copy strings and convert to strings

```c
int printf(char *format, ...)
int snprintf(char *buffer, int bufsize, char *format, ...)
```

- `snprintf(dest_str, max_size, "%s", src_str);` // copy string
- `snprintf(dest_str, max_size, "%d", int_var);` // int -> string
- `snprintf(dest_str, max_size, "%f", float_var);` // float -> string
Question

• How do we declare an array of strings?
Arrays of arrays

• Array of string (char*) pointers
  - Two (roughly) equivalent syntax choices
    • char *name[];
    • char **name;
  - Must allocate/initiialize each sub-array separately

• Command-line parameters
  • int main (int argc, char *argv[])
  - Example: "/program -a myfile.txt"
    • argc = 3
    • argv[0] = "/program"
    • argv[1] = "-a"
    • argv[2] = "myfile.txt"
```c
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#define STR_LEN 8

int main(int argc, char **argv)
{
    // check parameters
    if (argc != 3) {
        fprintf(stderr, "Usage: ./hello2 <fname> <lname>\n");
        exit(EXIT_FAILURE);
    }

    // convert name to "First L." format
    char fullname[STR_LEN];
    snprintf(fullname, STR_LEN, "%s %c.", argv[1], argv[2][0]);

    // output new full name
    printf("Hello, %s!\n", fullname);

    return EXIT_SUCCESS;
}
```