# Computer Science I

## Strings

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# Outline



1. Introduction
2. Manipulating Strings
3. String Processing
4. Data Processing
5. Exercises

# Part I: Introduction

# Strings



- A *string* is a sequence of *characters*

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- We'll stick with ASCII

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  - Static strings: `char s[100];`
  - Static string and initialization: `char s[] = "Hello";`
  - Dynamic strings: `char *s;`
  - Constant Strings: `char *s = "Hello";` Don't do this

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- Most of your strings will be of this type

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- Creates a *read-only, immutable* string
- Actually uses `const char *s = "Hello";`
- But the compiler generally doesn't catch it!
- Avoid unless you *really want* a dynamically allocated, immutable string for some reason

# Manipulating Strings by Character



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- Demonstration

# Manipulating Strings by Character



```c
char message[] = "hello World!"; //size is 13

message[0] = 'H';
//bad:
message[0] = "H";
printf("message = %s\n", message);

//cut the string short:
message[5] = '\0';
printf("message = %s\n", message);

//restore it: the rest of the contents were unchanged
message[5] = ' ';
printf("message = %s\n", message);

message[11] = '?';
printf("message = %s\n", message);

//bad:
message[12] = '!';
printf("message = %s\n", message);

//really bad:
message = "Goodbye World!";
```

# Part II: String Manipulation

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- A string is a character array which is a *memory address*

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```
1  char *name = (char *) malloc(sizeof(char) * 10);
2
3  strcpy(name, "Chris");
4  strcpy(name, "Bourke");
5  //invalid:
6  strcpy(name, "Chris Bourke");
```

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1  char message[] = "Hello World!";
2  int n = strlen(message);
3  printf("n = %d\n", n);
4  message[5] = '\0';
5  n = strlen(message);
6  printf("n = %d\n", n);
7
8  char * stringCopy(const char *s) {
9    char *copy = (char *) malloc(sizeof(char) * (strlen(s) + 1));
10   strcpy(copy, s);
11   return copy;
12 }
```

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```
1  char *firstName = (char *) malloc((5+1) * sizeof(char));
2  char *lastName = (char *) malloc((6+1) * sizeof(char));
3  char *str = (char *) malloc(101) * sizeof(char));
4
5  strcpy(firstName, "Chris");
6  strcpy(lastName, "Bourke");
7
8  strcpy(str, lastName);
9  strcat(str, ", ");
10 strcat(str, firstName);
11 //str contains "Bourke, Chris"
```

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```
1  char fullName[] = "Christopher";
2  char *nickName[] = (char *) malloc(6 * sizeof(char));
3
4  strncpy(nickName, fullName, 5);
5  //don't forget:
6  firstName[5] = '\0';
```

# Part III: String Processing

# Iterating Over Strings



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```
1   //straightforward code:
2   for(int i=0; i<strlen(s); i++) {
3     printf("%c\n", s[i]);
4   }
5
6   //strlen works like:
7   int i = 0;
8   while(s[i] != '\0') {
9     i++;
10  }
11  //the value of i equals strlen(s)
12
13  //optimized:
14  int n = strlen(s);
15  for(int i=0; i<n; i++) {
16    printf("%c\n", s[i]);
17  }
18
19  //even better:
20  for(int i=0; s[i] != '\0'; i++) {
21    printf("%c\n", s[i]);
22  }
```

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- Automatically type casted

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- `int tolower(int c)`, `int toupper(int c)` – return the ASCII text value of the lowercase/uppercase version of `c`

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- `int tolower(int c)`, `int toupper(int c)` – return the ASCII text value of the lowercase/uppercase version of `c`
- Demonstration: write a code snippet to count the number of spaces and the total number of whitespace characters.

# ctype library



```
1  char str[] = "Hello how \n\t are you today? \n\n";
2  int numSpaces = 0;
3  int numWhiteSpaces = 0;
4
5  for(int i=0; s[i] != '\0'; i++) {
6    if(isspace(s[i])) {
7      numWhiteSpaces++;
8    }
9    if(s[i] == ' ') {
10     numSpaces++;
11   }
12 }
13 printf("number of spaces: %d\n", numSpaces);
14 printf("total whitespace: %d\n", numWhiteSpaces);
```

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- Returns:
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# String Comparisons



```
1  int result;
2
3  result = strcmp("apple", "apple"); //0
4  result = strcmp("apple", "apples"); //negative
5  result = strcmp("apples", "apple"); //positive
6  result = strcmp("Apple", "apple"); //negative
7  result = strcmp("apples", "oranges"); //negative
8
9  result = strcmp("100", "99"); //negative!
10
11 result = strncmp("apple", "apples", 5); //zero
12
13 result = strcasecmp("ApPlE", "apple"); //zero
```

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# Substrings



```
1  char name[] = "Margaret Hamilton";
2  char *lastName = &name[9];
3  printf("Greetings, Ms. %s\n");
```

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- Demonstration

# Formatting Strings



```
1  char s[100]; //buffer that is "big enough"
2  char state[] = "Nebraska";
3  int numCounties = 93;
4  double population = 1.92;
5  sprintf(s, "%s has %d counties and a population of %.2f million.\n", st
```

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# Arrays of Strings



```
1  char **names = (char **) malloc(sizeof(char*) * 5);
2  names[0] = stringCopy("Margaret Hamilton");
3  names[1] = stringCopy("Grace Hopper");
4  names[2] = stringCopy("Alan Turing");
5  names[3] = stringCopy("Ada Lovelace");
6  names[4] = stringCopy("Dennis Ritchie");
7  for(int i=0; i<5; i++) {
8    printf("Famous Computer Scientist: %s\n", names[i]);
9  }
```

# Part IV: Data Processing

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# String Tokenization



```
1  char str[] = "Hedy,Lamarr,UNL,Avery Hall,Lincoln,NE";
2  char *token = NULL;
3  token = strtok(str, ",");
4  while(token != NULL) {
5    printf("token = %s\n", token);
6    token = strtok(NULL, ",");
7  }
```

# Part V: Exercises

- Write a string function to change a string's characters to uppercase letters
- Write a string function that returns a new copy of a string with all characters converted to uppercase
- Write a string function to "double space" a paragraph
- Write a "split"-style function: it takes a string and a delimiter and returns an array of strings of the tokens. Ensure no memory leaks!