CSCI 200: Foundational Programming Concepts & Design Lecture 32

Static Arrays

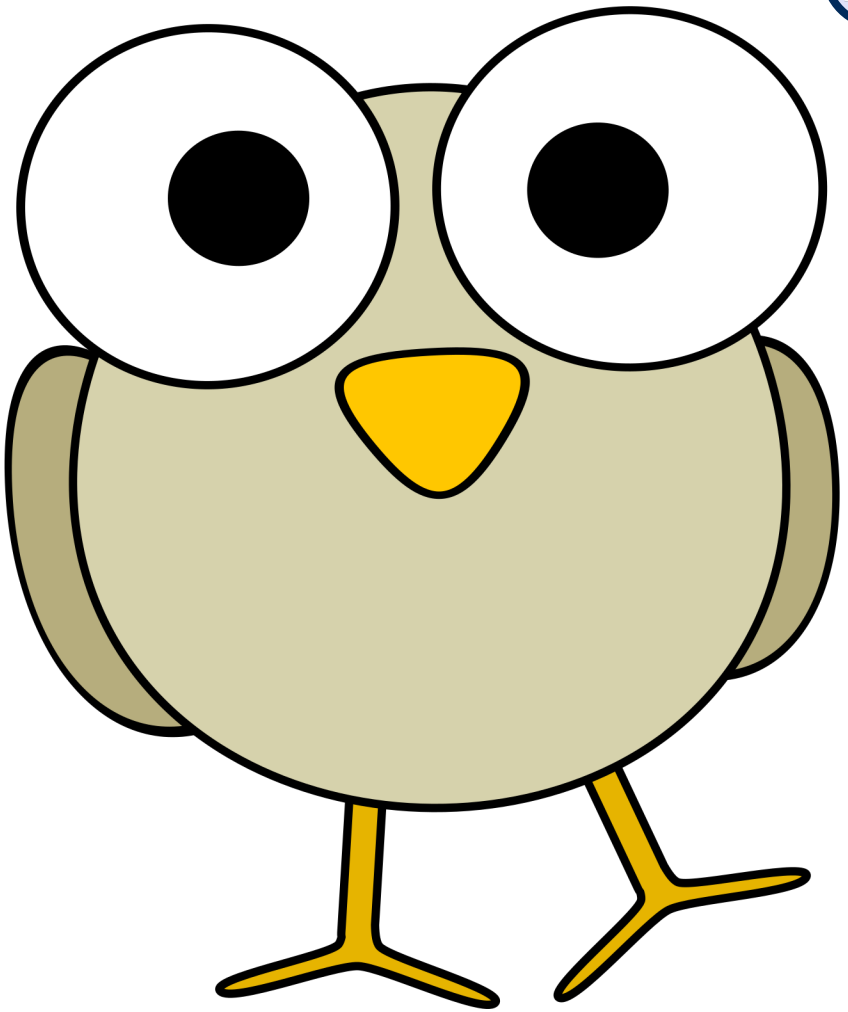
Canvas 11/08 Arrays Survey Access Code: **USB**

Download handout for the day

Previously in CSCI 200

- Design Principles
  - Abstract what's the same, encapsulate what varies.
  - Program to an interface, not an implementation
  - SOLID Principles
    - Single Responsibility Principle
    - Open/Closed Principle
    - Liskov Substitution Principle
    - Interface Segregation Principle
    - Dependency Inversion Principle
  - Favor composition over inheritance.

Questions?



Learning Outcomes For Today

- Evaluate the resultant output of a given code block containing an array.
- Sketch how an array is stored in memory denoting the base address and element step size.
- Construct a program using an array.
- Identify errors in a program involving an array.
- Analyze array operations using Big O Notation.

On Tap For Today

- Static Arrays (fixed size)
  - Creation
  - Memory Layout & Elemental Access
  - Special Case: Character Arrays
- Practice

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Static Arrays

- Simple “list-like” data structure
  - Fixed Size known at compile time
  - All elements are the same type

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Declaring an Array

- "Computer, create an array called stores to hold 10 integers"

```
int stores[10];
```

- "Computer, create an array called temps to hold 365 doubles"

```
double temps[365];
```

Declare & Initialize an Array

- "Computer, create an array called omg to store three characters. Here are three characters to put in the array."

```
char omg[3] = {'O', 'M', 'G' };
```

- "Computer, create an array called count that holds 5 integers. Here are five integers to put in the array."

```
int count[5] = {1, 7, 4, 2, 3};
```

Initialize an Array

- "Computer, create an array called temp that will hold 365 doubles. Initialize ALL values to zero."

```
double temp[365] = {0};
```

Practice!

```
int myCount[15];
```

Practice!

```
int myCount[15];                    // declare myCount
                                    // that holds 15 ints
double cool[2] = {2.5, 3.5};        // holds 2 doubles
                                    // set to 2.5, 3.5
char myChar[4] = {'A'};             // holds 4 chars and
                                    // init the 1st element
                                    // to 'A', rest to 0
int z[] = {1, 2, 3};                // computer assumes an
                                    // array size of 3
```

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Variables in Memory

- Every variable stored in memory (somewhere)
- Identifier points to memory address where value is stored
- How much memory does variable take up?
  - Depends on data type

Arrays in Memory

- "Computer, allocate enough contiguous memory for three integers. When I want a value, I'll ask for it by name and offset."

```
int scores[3];
```

Arrays in Memory

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```
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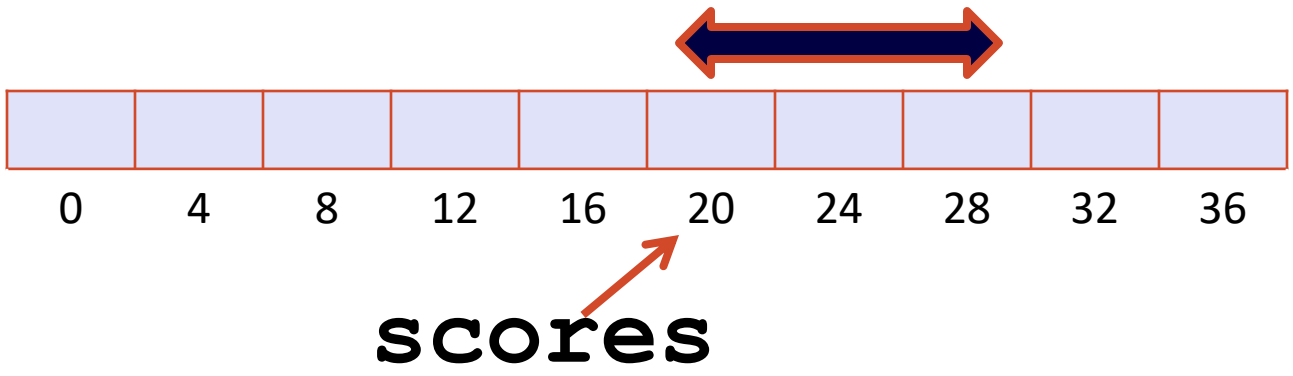
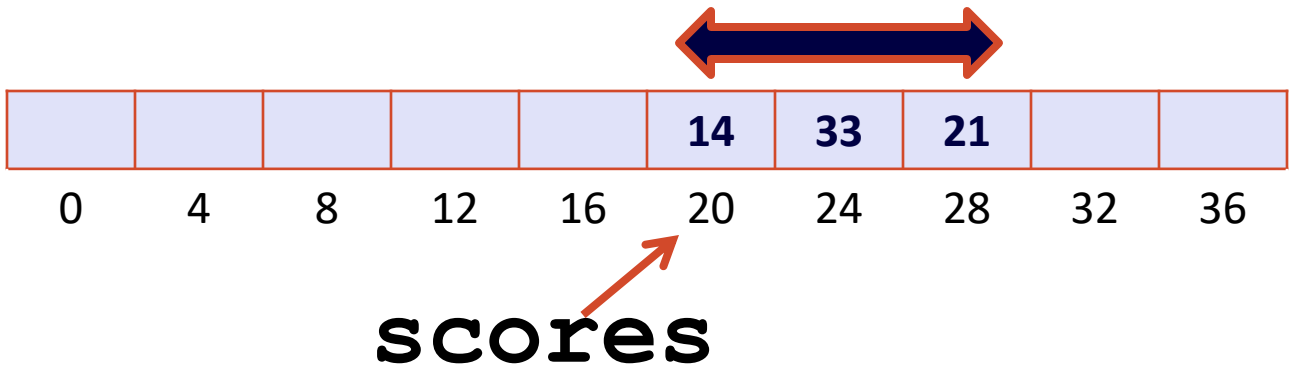


(These addresses and the size of each box are just an example.)

Arrays in Memory

- "Computer, allocate enough contiguous memory for three integers. When I want a value, I'll ask for it by name and offset."

```
cout << scores[1];
```



(These addresses and the size of each box are just an example.)

Arrays in Memory

identifier / name[offset]	memory address	value
	0x4f83821c	
scores / scores[0]	0x4f838220	14
scores[1]	0x4f838224	33
scores[2]	0x4f838228	21
	0x4f83822c	
	0x4f838230	

- The array identifier points to the base address of the array

Arrays in Memory

identifier / name[offset]	memory address	value
	0x4f83821c	
scores / scores[0]	0x4f838220	14
scores[1]	0x4f838224	33
scores[2]	0x4f838228	21
	0x4f83822c	
	0x4f838230	

- The offset is used to calculate the location of an individual element

Finding an Element in Memory

- The array identifier points to the base address of the array
- The offset is used to calculate the location of an individual element
- How much to offset?

$$elementAddress = baseAddress + (dataTypeSize * offset)$$

Demo

```
const int SIZE = 3;

int myArray[SIZE] = { 34, 5, 678 };

cout << myArray << endl << endl;

for( int i = 0; i < SIZE; i++ )

   cout << "myArray[" << i << "] is:"
        << myArray[i] << endl;


for( int i = 0; i < SIZE; i++ )

   cout << "The address of myArray["
        << i << "] is:" << &myArray[i]
        << endl;
```

Accessing Array Values

- "Computer, print the value at position 0 in scores"

```
int scores[2] = { 4, 2 };

cout << scores[0];
```

Accessing Array Values

- "Computer, add the values in scores and assign to sum"

```
int scores[2] = { 4, 2 };

int sum;

sum = scores[0] + scores[1];
```

Setting Array Values

- "Computer, assign the value 5 to position 0"
- "Computer, assign the value 100 to position 1";

```
int scores[2];

scores[0] = 5;

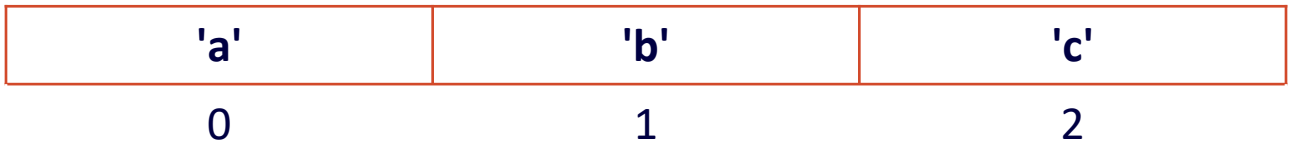
scores[1] = 100;
```

Precedence Table

Precedence	Operator	Associativity
1	Parenthesis: ( )	Innermost First
2	Postfix Unary Operators: a++ a-- a[ ] a. f() p->	Left to Right
3	Prefix Unary Operators: ++a --a +a -a !a (type)a &a *p new delete	Right to Left
4	Binary Operators: a*b a/b a%b	Left to Right
5	Binary Operators: a+b a-b	
6	Relational Operators: a<b a>b a<=b a>=b	
7	Relational Operators: a==b a!=b	
8	Logical Operators: a&&b	
9	Logical Operators: a||b	
10	Assignment Operators: a=b a+=b a-=b a*=b a/=b a%=b	Right to Left

Accessing Array Values

- Arrays have *indices* that refer to its values



- Array indices start with 0
- Array indices start with 0
- Array indices start with 0

Common Errors

```
int v[2] = { 4, 2 };

cout << v[5];     // index out of range

cout << v[-1];    // index out of range

cout << v[2];     // index out of range

int x[]; // no size and no init values


// In C++ you CANNOT change a static
// array's size after you declare it
```

Practice

- Runtime to
  - Access an element in an array?
  - Traverse an array?

Data Structure Operations

Operation	Array
Element Access	$O(1)$
Traversal	$O(n)$
Search	$O(n)$
Min / Max	$O(n)$

Practice

- Work through handout

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Arrays & Loops

- Need to iterate over array to input or output all the elements one at a time

```
const int SIZE = 15;
int myIntArray[SIZE];
for(int i < 0; i < SIZE; i++)
  cin >> myIntArray[i];
for(int i < 0; i < SIZE; i++)
  cout << myIntArray[i] << endl;
```

- Except...
  - ...if array type is a character

C Strings I/O

```
const int SIZE = 15;

char myCString[SIZE] = "I Love C++!";

cout << myCString << endl;

cout << "Enter a new string: ";

cin >> myCString;

cout << myCString << endl;
```

C-Style String

- Special case when array type is char
  - Size of string must still be known up front

```
const int SIZE = 15;
char myCString[SIZE] = "I Love C++!";
```

  - (Ends in '\0' aka null terminator)

String Functions

- Commonly used functions

```
#include <cstring>
```

```
strlen();

strcpy();

strcat();

strcmp();
```

String Functions

- Commonly used functions

```
#include <cstring>

char myS[20] = "Hi!";
char myS1[7] = "Hey!", myS2[5];

strlen();           cout << strlen(myS) << endl;
strcpy();           strcpy( myS2, myS1 );
strcat();           strcat( myS, myS1 );
strcmp();           if( strcmp( myS, myS1 ) < 0 )
```

C Strings I/O

```
const int SIZE = 15;

char myCString[SIZE] = "I Love C++!";

cout << myString << endl;

cout << "Length: "
     << strlen( myCString ) << endl;

cin >> myString;

cout << myString << endl;

cout << "Length: "
     << strlen( myCString ) << endl;
```

Size of a `char` Array

- RULE: You should NOT exceed the bounds of the array

```
int myArray[10];
char myCString[10];


myArray[10] = 5;            // NOT OK!
cout << myCString[20];      // ERROR!
```

Size of a `char` Array

- RULE: You should NOT exceed the bounds of the data stored

```
char myCString[10] = "Hi!";


cout << myCString[6];     // ERROR!
```

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To Do For Next Time

- Continue on Set5 and Final Project

- 11/15 Quiz 5 - Inheritance