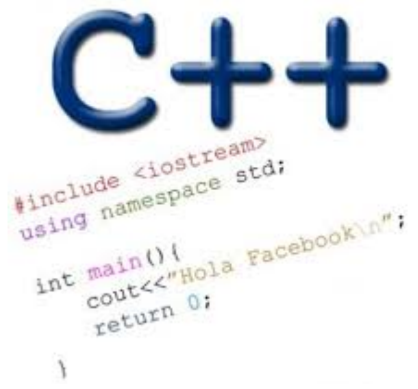
VISUALIZING PROGRAM DYNAMICS ARRAYS

Problem Solving with Computers-I

https://ucsb-cs16-wi17.github.io/



```
#include <iostream>
using namespace std;

int main(){
    cout<<"Hola Facebook\n";
    return 0;
}
```

GitHub

Reflecting on the midterm

- The question paper is on the course website: https://ucsb-cs16-wi17.github.io/exam/e01/
- Overall – it was a good performance! Mean: 85.57%, median 87.33%, std. deviation: 9.68%
- Lab04 is now available – all about arrays!
- Hw08 is also all about arrays and tracing code!

Memory and C++ programs

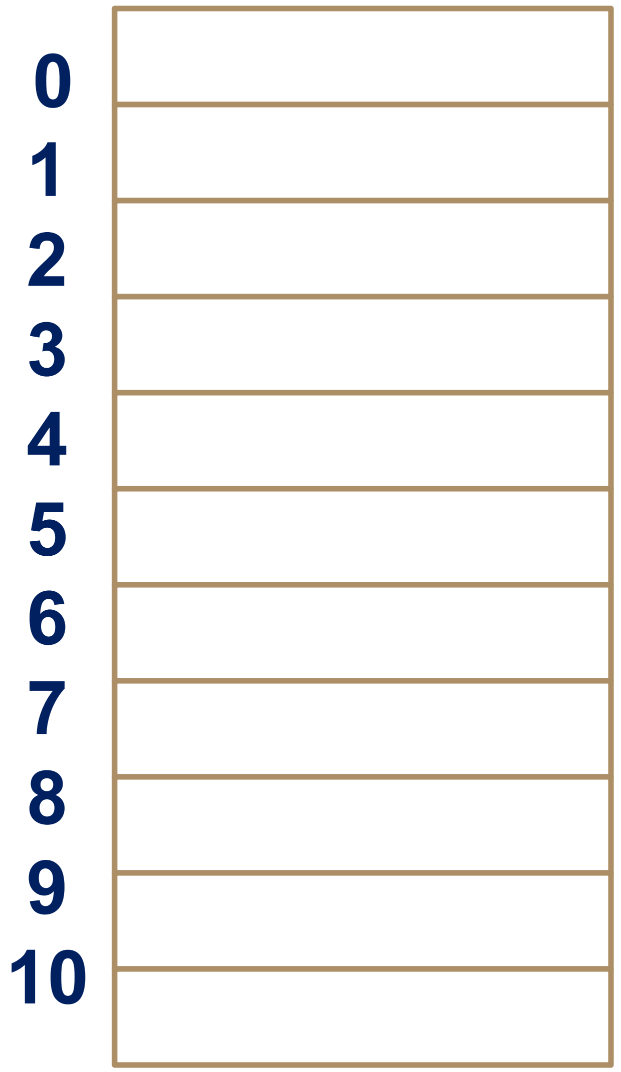
“*The overwhelming majority of program bugs and computer crashes stem from problems of memory access... Such memory-related problems are also notoriously difficult to debug. Yet the role that memory plays in C and C++ programming is a subject often overlooked…. Most professional programmers learn about memory entirely through experience of the trouble it causes.*”

…. Frantisek Franek

(Memory as a programming concept)

Model of memory

- Sequence of adjacent cells
- Each cell has bits stored in it
- Each cell has an address (memory location)



Interaction of programs with memory

Consider the declaration: `int x;` `//`Assume starting location of ‘x’ is 0

Memory map below would result from which of the following C++ statements?

0	0xFF
1	0xFF
2	0xFF
3	0xFE
4	0x01
5	0x02
6	0x03
7	0x04

State of memory after code execution

A. `int x = 0xFF;`

B. `int x = 0xFE;`

C. `int x = 0xFFFFFFFE;`

D. `int x = -2;`

E. Both C and D

Tracing code

Show how the state of memory is modified when the following C++ code is executed?

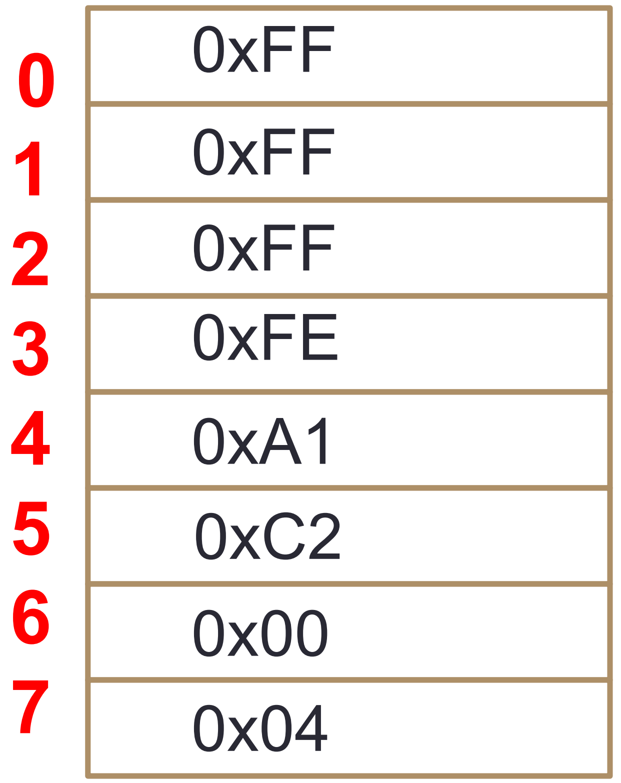
0	0xFF
1	0xFF
2	0xFF
3	0xFE
4	0x01
5	0x02
6	0x03
7	0x04

State of memory

```
int x = 1;  // Assume x is at location 0
char y;     // Assume y is at location 7
if(x>0)
    x++;
else
    y++;
```

Drawing memory maps to trace code

- Trace the code below by drawing memory diagrams
- Choose the level of abstraction in your diagram that’s right for this context!

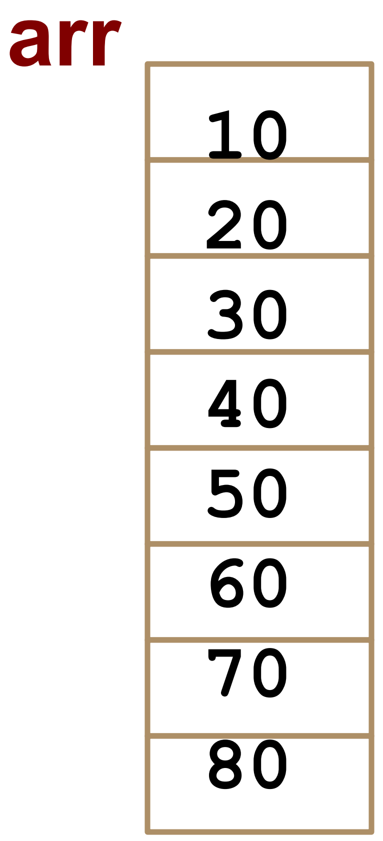


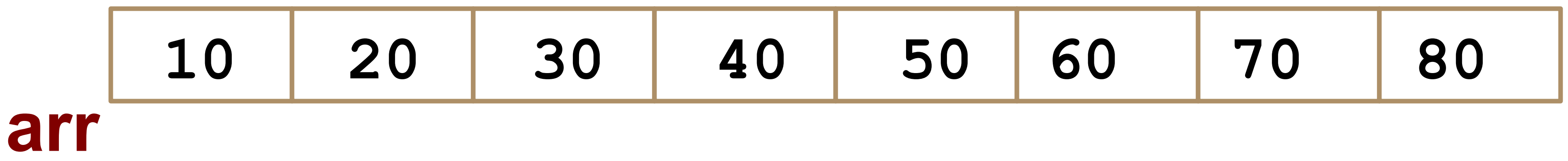
0	0xFF
1	0xFF
2	0xFF
3	0xFE
4	0xA1
5	0xC2
6	0x00
7	0x04

```
char x = -2;
char y = 4;
char tmp = x;
x = y;
Y = tmp;
```

C++ Arrays

A C++ array is a **list of elements** that share the same name, have the same data type and are located adjacent to each other in memory





Declaring C++ arrays

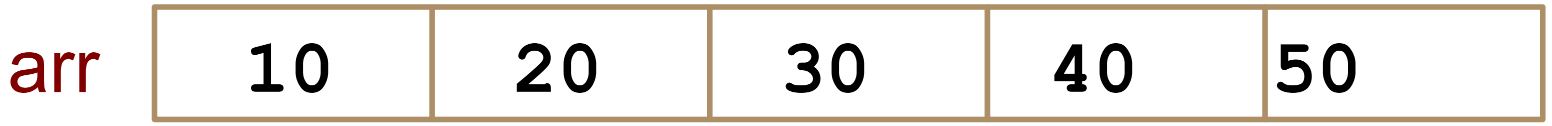
```
int arr[5];           // declares a 5-element integer array
```

Declaring and initializing C++ arrays

// Declare a 5-element integer array and fill it with values

```
int arr[5]={10, 20, 30, 40, 50};
```

What is the memory location of each element?

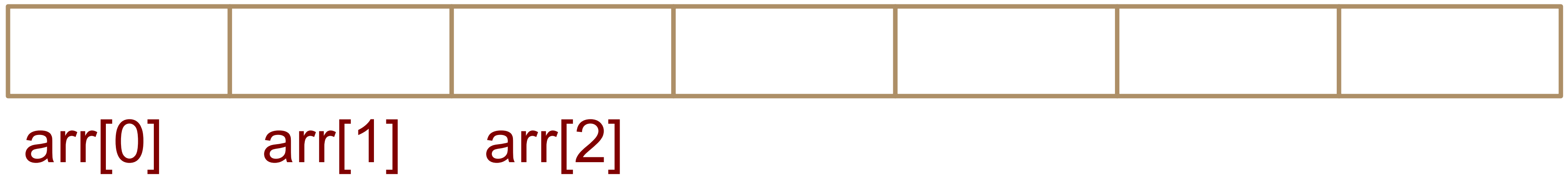


```
int arr[5]={10, 20, 30, 40, 50};
```

If the starting location of the array is 0x200, what is memory location of element at index 2?

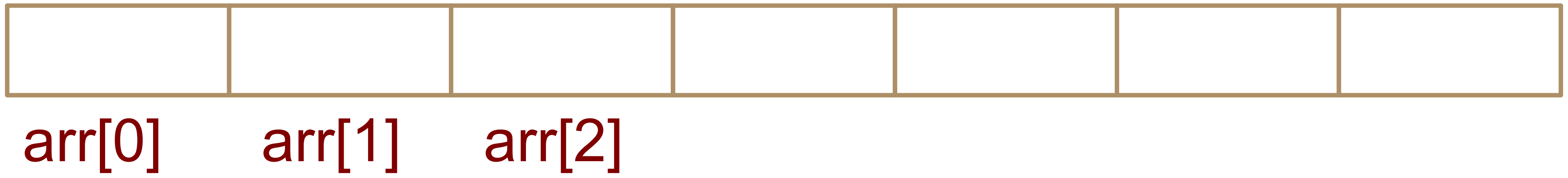
A. 0x201
B. 0x202
C. 0x204
D. 0x208

Accessing elements of an array



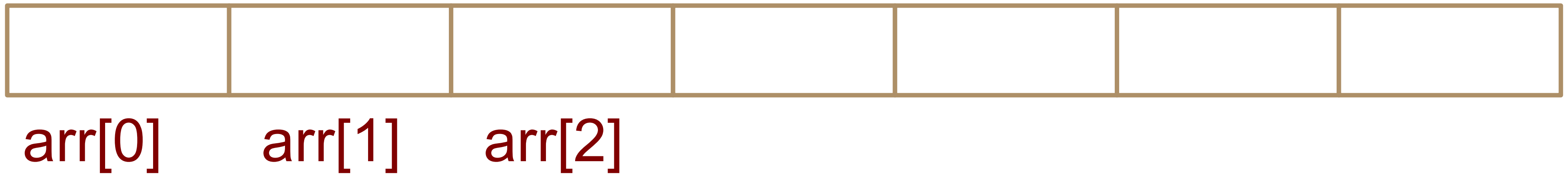
```
int arr[]={1,2,3}; // declare an initialize
//Access each element and reassign its value to 5
```

Most common array pitfall- out of bound access



```
int arr[]={1,2,3}; // declare an initialize
arr[3] = 5;
```

Using variables as array subscripts



```
int arr[]={1,2,3};
//increment each element of the array
```

Tracing code involving arrays

arr[0]	arr[1]	arr[2]

```
int arr[]={1,2,3};
int tmp = arr[0];
arr[0] = arr[2];
arr[2] = tmp;
```

Choose the resulting array after the code is executed

A.

1	2	3
arr[0]	arr[1]	arr[2]

B.

2	1	3
arr[0]	arr[1]	arr[2]

C.

3	2	1
arr[0]	arr[1]	arr[2]

D. None of the above

Arrays - motivation

DEMO: Write a program to store 5 scores and calculate the average of the 5 scores.

Passing arrays to functions

Write the declaration of a function that takes an array of scores as parameter and returns the average of the scores

Pointers

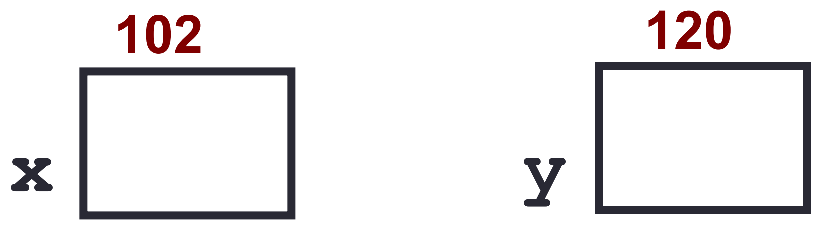
- Pointer: A variable that contains the address of a variable
- Declaration: *type* * pointer_name;

```
int *x;
```

How do we initialize a pointer?

How to make a pointer point to something

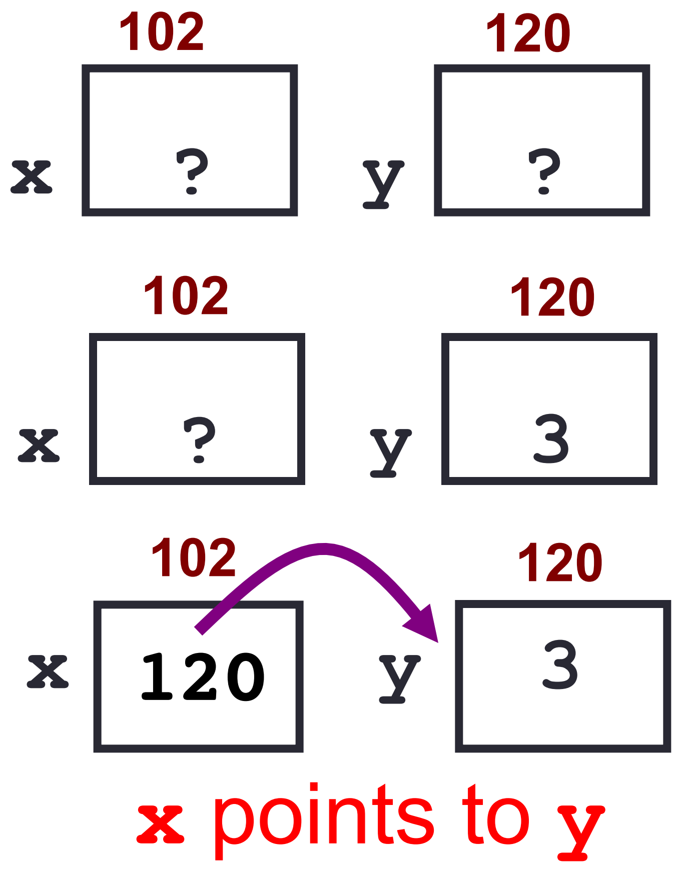
```
int *x;
int y=20;
```



//To access the location/address, use the address operator ‘&’

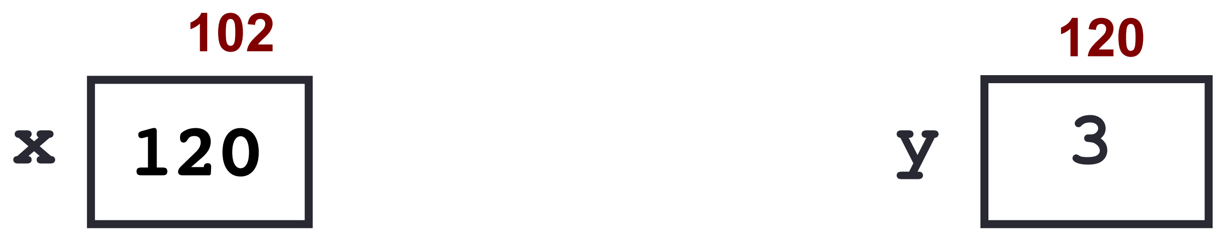
How to make a pointer point to something

```
int *x, y;

y = 3;

x = &y;
```



```
sizeof(x)=
```

Pointer Diagrams

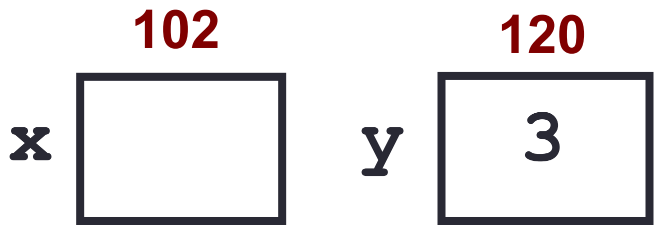


- Short hand diagram for the above scenario

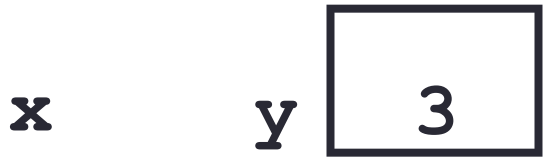
To change the value of a variable using pointers:

use dereference * operator to left of pointer name

```
int y=3;
int *x
```

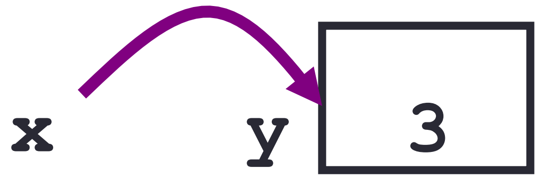


```
x= &y;
```



```
*x = 5;
```

- Two ways of changing the value of any variable
- Why this is useful will be clear when we discuss functions and pointers



Change the value of y directly:

Change the value of y indirectly (via pointer x):

Next time

- Pointers
- Mechanics of function calls – call by value and call by reference