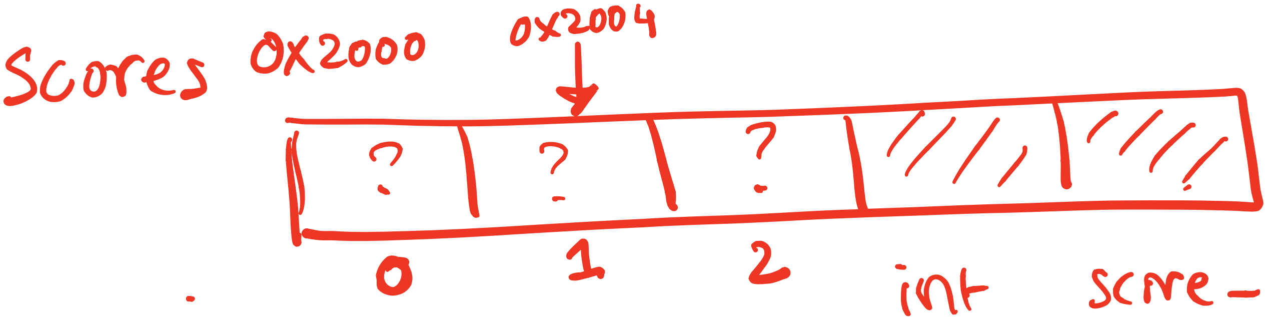
C++ ARRAYS POINTERS

Problem Solving with Computers-I

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

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

C++ Arrays

- **List of elements**
- All elements have the same data type
- The elements are located adjacent to each other in memory
- Like all variables in C++, you must declare an array before using it



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

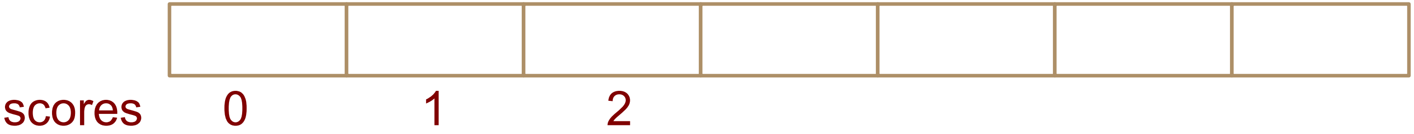
```
int scre_1;
int score_2;
int score_3;
```

Accessing elements of an array

`int scores[]={20,10,50};` // declare and initialize

- **`scores` is the starting memory location of the array**
  - **also called the base address**
  - **Base address (`scores`) cannot be modified**
- **Access array elements using their index**
- **Indices start at 0**
  - **scores[0]: 20**
  - **scores[1]: 10**
  - **scores[2]: 50**
  - **scores[3]: out of bound array access, undefined behavior**

Iterating through an array



```
int scores[]={20,10,50}; // declare an initialize
```

To iterate use:

- * **regular for loops**
- * **Or range based for loop (C++ 11 feature)**

Modifying the array

Cannot change the base address

What is the output of this code?

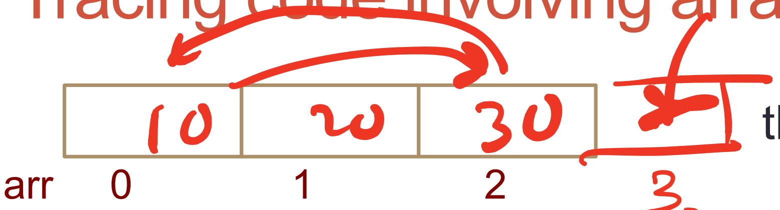
```
int scores[]={20,10,50};
scores = scores + 10;
for(int i=0; i<3; i++){
    cout<<scores[i]<<“\t”;
}
```

A. 30 20 60

B. 20 10 50

[✓ C. Compiler error]

Tracing code involving arrays



arr[3] ← out of bound access

```
int arr[]={10,20,30};
int tmp = arr[0];
arr[0] = arr[2];

arr[2] = tmp;
```

Choose the resulting array after the code is executed

A.

arr	0	1	2
	10	20	30

B.

arr	0	1	2
	20	10	30

[✓ **C.**]

arr	0	1	2
	30	20	10

D. None of the above

Most common array pitfall- out of bound access

scores[0]   scores[1]   scores[2]

```
int scores[]={20,10,50}; // declare an initialize
for(int i=0; i<=3; i++)
    scores[i] = scores[i]+10;
```

Passing arrays to functions

scores	10	20	30	40	50

0x2000

↑ base address

```
int main(){
   int scores[]={10, 20, 30, 40, 50};
   foo(scores);
}
double foo(int sc[]){
    cout<<sc;
    return
}
```

What is the output?

A. 10
B. 10 20 30 40 50
[✓ C.] 0x2000
D. None of the above

Remember: The name of the array is simply the address of element no. 0 (also called the base address)

Pointers

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

```
int* p;
```

// Declare

p is a pointer to an integer

means:

p stores the location of an integer

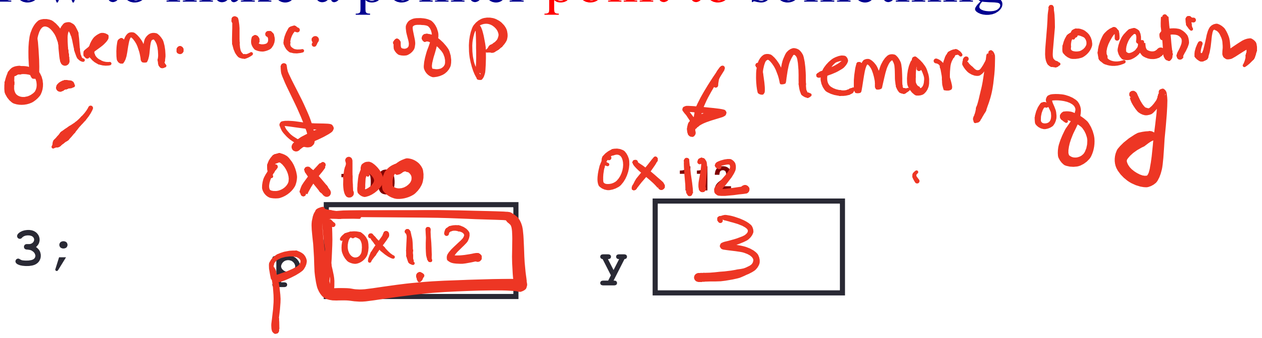
How to make a pointer point to something

int x = 10.

```
int *p;
int y = 3;
```

p = &y;

↑ Address of y



Mem. loc. of p

0x100

p

0x112

Memory location of y

0x112

y

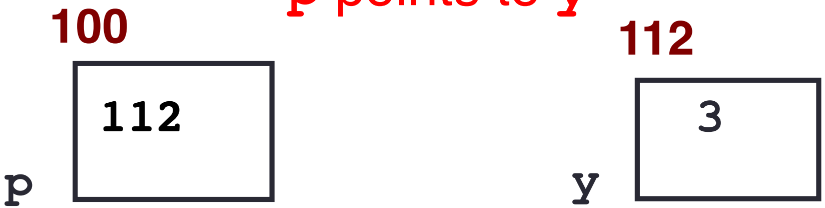
3

To access the location of a variable, use the address operator ‘&’

Pointer Diagrams:
Diagrams that show the relationship between pointers and pointees

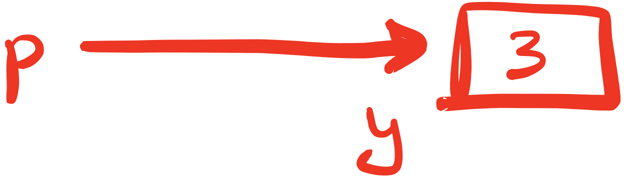
p points to **y**

Pointer: p



Pointee: y

The short hand representation for the above situation is:

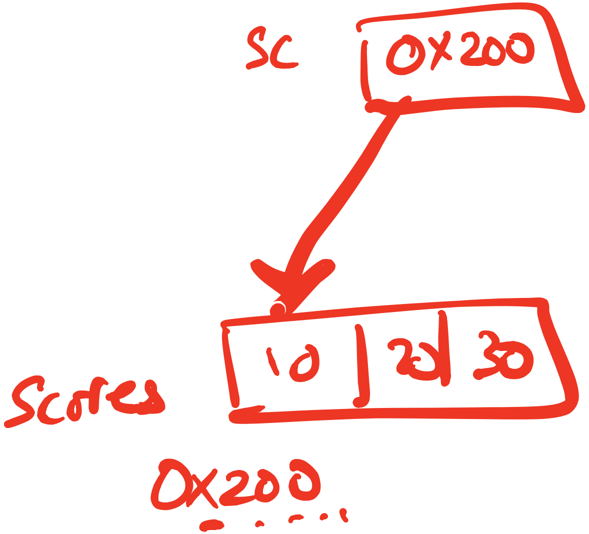


p points to y

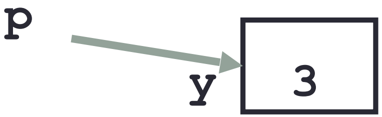
You can change the value of a variable using a pointer !

```
int *p, y;
y = 3;
p = &y;

*p = 5;
```

```
void print ( int* sc) {
    // code
}

print(scores);
```



Two ways of changing the value of a variable



- Change the value of y directly:

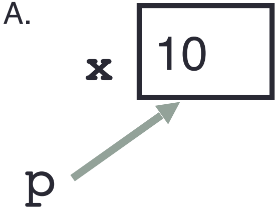
- Change the value of y indirectly (via pointer p):

Tracing code involving pointers

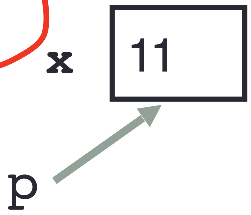
```
int *p;
int x=10;
p = &x;
*p = *p + 1;
```

Q: Which of the following pointer diagrams best represents the outcome of the above code?

A.



[✓ B.]



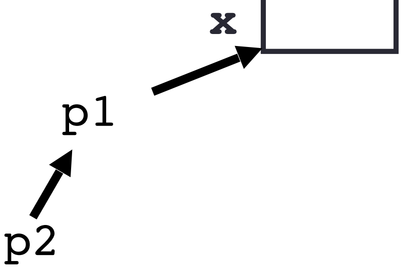
C. Neither, the code is incorrect

Pointer assignment

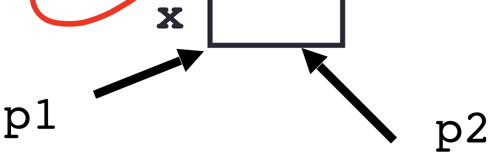
```
int *p1, *p2, x;
p1 = &x;
p2 = p1;
```

Q: Which of the following pointer diagrams best represents the outcome of the above code?

A.

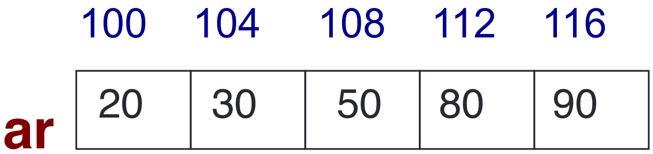


[✓ B.]



C. Neither, the code is incorrect

Arrays and pointers



	100	104	108	112	116
ar	20	30	50	80	90

- `ar` is like a pointer to the first element
- `ar[0]` is the same as `*ar`
- `ar[2]` is the same as `*(ar+2)`

- Use pointers to pass arrays in functions
- Use *pointer arithmetic* to access arrays more conveniently

Pointer Arithmetic

```
int ar[]={20, 30, 50, 80, 90};
```

How many of the following are invalid?

I. pointer + integer (ptr+1)
II. integer + pointer (1+ptr)
III. pointer + pointer (ptr + ptr)
IV. pointer – integer (ptr – 1)
V. integer – pointer (1 – ptr)
VI. pointer – pointer (ptr – ptr)
VII. compare pointer to pointer (ptr == ptr)
VIII. compare pointer to integer (1 == ptr)
IX. compare pointer to 0 (ptr == 0)
X. compare pointer to NULL (ptr == NULL)

#invalid

A: 1
B: 2
C: 3
D: 4
E: 5

Pointer Arithmetic

```
int ar[]={20, 30, 50, 80, 90};
int *p;
p = arr;
p = p + 1;
*p = *p + 1;
```

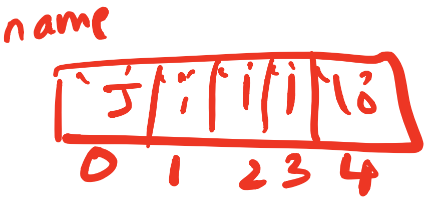
Draw the array ar after the above code is executed

char arrays, C-strings

- How are ordinary arrays of characters and C-strings similar and how are they dissimilar?

C-strings are an array of characters where the last character is a null terminator '\0' (ASCII value 0)

```
char name[] = "Jill";
```



name

'J'	'i'	'l'	'l'	'\0'
0	1	2	3	4

What is the output of the code?

```
char s1[] = "Mark";
char s2[] = "Jill";
for (int i = 0; i <= 4; i++)
     s2[i] = s1[i];
if (s1 == s2) s1 = "Art";
cout<<s1<<" "<<s2<<endl;
```

s1 is an array of characters

cannot change the base addres

A. Mark Jill

B. Mark Mark

C. Art Mark

[✓ D. Compiler error]

E. Run-time error

Two important facts about Pointers

1) A pointer can only point to one type –(basic or derived) such as `int`, `char`, a `struct`, another pointer, etc

2) After declaring a pointer: `int *ptr;`

   `ptr` doesn’t actually point to anything yet.

   We can either:

   ➢ make it point to something that already exists, OR

   ➢ allocate room in memory for something new that it will point to

Pointer Arithmetic

- What if we have an array of large structs (objects)?
  - C++ takes care of it: In reality, `ptr+1` doesn't add `1` to the memory address, but rather adds the size of the array element.
  - C++ knows the size of the thing a pointer points to – every addition or subtraction moves that many bytes: 1 byte for a char, 4 bytes for an int, etc.

Next time

- References
- Call by value, call by reference and call by address