Phys4051: C Lectures

Pointers and Address Operators
Pointer to a Variable
Function Calls: Passing by Value and Passing by Reference
Pointer to an Array

1

Pointers and Variables: Definition

Variable:

- A **variable** refers to a memory location that contains a **numerical value**.

Pointer

- A **pointer** refers to a memory location that contains an **address**.

2

Pointers: Operators (1)

- Address Operator: **&**
  - Note: it looks identical to the bitewise AND operator but it is used in a completely different way!
  - Returns the address of a variable
  - Example: `prt_v = & x;`

3

Pointers: Operators (2)

- Indirection Operator: ***
  - Note: it looks identical to the multiplication operator but it is used in a completely different way!
  - Retrieves a value from the memory location the pointer points to.
  - Example: `*ptr_v = 77;`

4

Pointer Declaration

- A pointer must be declared and the variable **type** it points to must be specified:

```
short *aptr;  //pointer declaration
double *bptr;
float* fptr;   //same as float *fptr
```

5

Assigning an Address to a Pointer (1)

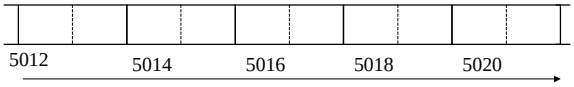
- An address is assigned to a pointer using the address operator: &

6

Assigning an Address to a Pointer (2)

- Example:

```
short x = 33;
short *aptr; //pointer declaration
aptr = & x;
```



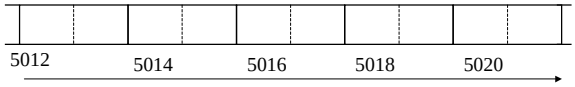
(The memory addresses are arbitrarily chosen)

7

Pointer Usage with a Variable: Indirection Op.

- Example:

```
short x = 33;
short *aptr;    //declare the ptr
aptr = & x;     //ptr points to x
*aptr = -123;   //assign a value to "x"
```



(The memory addresses are arbitrarily chosen)

8

Pointer Usage with a Variable:

- The following two segments are equivalent in respect what they do to variable "*x*":

```
short x = 33;
short *aptr;
aptr = & x;
*aptr = -123;
```

```
short x = 33;


x = -123;
```

9

Pointers: Additional Comment

- Pointers refer to an address which is almost always the address of another variable.
- An (arbitrary) address can be directly assigned to a pointer. Doing so makes the program less portable and can be very dangerous!
- Example:

```
short *aptr = 0x300;
*aptr = 0xff;
```

10

Pointers: Function Calls and Function Arguments

- Variables can be passed to a function (as function arguments) either:
- a) **by value**
  - (as a copy of a local variable)
- b) **by reference**
  - (by a pointer)

11

Function Arguments: Passing by Value

- This is the method you have used so far in these examples.
- A (local) copy of the variable is passed to function.
- Changing the (passed) variable within the calling function has no effect on the (original) variable that was passed.

12

Ex. 1: Exchange Two Variables: By Value

- Problem:
- a) Write a function "Xchange" that will exchange two variables if the "first" variable is greater than the "second" one.
- b) You are not allowed to use GLOBAL variables!

13

Ex. 1a: Exchange Two Variables (2): main

```
void Xchange_ByVal(short u,
                   short v);
main()
  {
  short x = 10, y = 2;
  Xchange_ByVal(x, y);
  printf("x: %d  ", x);
  printf("y: %d\n", y);
  }
```

14

Ex. 1a: Exchange Two Variables (3): Function

```
void Xchange_ByVal(short u,
                   short v )
{ short stemp;
  if( u > v){
     stemp = v; v = u; u = stemp;
     }
  printf("u: %d  ", u);
  printf("v: %d\n", v);
}
```

15

Ex. 1a: Exchange Two Variables (4): Output

- Output:

  u: v:

  x: y:
- Conclusion: Works? (y/n)
- Why (not)?

16

Function Arguments: Passing by Reference

- Allows you to change the value of a variable which is not local to the function without having to make it global
- Pass a reference (a pointer) to the function which tells the function where "to find" that variable
- Note: (usually) you don't change the reference, you change only what the reference points to!

17

Ex. 1b: Exchange Two Variables (5): By Reference

- **Solution:**

  Pass the function arguments by reference!

18

Ex. 1b: Exchange Two Variables (6): main

```
void Xchange_ByRef(short *u,
                   short *v);
main()
  {
  short x = 10, y = 2;
  Xchange_ByRef(&x, &y);
  printf("x: %d  ", x);
  printf("y: %d\n", y);
  }
```

19

Ex. 1b: Exchange Two Variables (7): Function

```
void Xchange_ByRef(short *u,
                   short *v )
{ short stemp;
  if( *u > *v){
     stemp = *v; *v = *u;
                  *u = stemp;
     }
  printf("u: %d  ", *u);
  printf("v: %d\n", *v);
}
```

20

Ex. 1b: Exchange Two Variables (8): Output

- Output:

  u: v:

  x: y:

- Conclusion: Works? (y/n)

21

Function Arguments and Pointers: Summary

- Passing (a Variable) by Value:
  - Variable is local to function and, therefore, can not alter the original value.
- Passing (a Variable) by Reference
  - Since a reference to the variable is passed, the original value can be accessed and altered.

22

Summary: Function Calls a) by Value

- Passing a Variable by Value:

```
void FbyVal( int );
main()
  {
  int y = 3;

  FbyVal(     );
  }
```

- Passing a Pointer by Value:

```
void FbyVal( int );
main()
  {
  int x = 3;
  int* y = &x;

  FbyVal(     );
  }
```

23

Summary: Function Calls a) by Reference

- Passing a Variable by Reference:

```
void FbyRef( int* );
main()
  {
  int y = 3;

  FbyRef(     );
  }
```

- Passing a Pointer by Refrerence:

```
void FbyRef( int* );
main()
  {
  int x = 3;
  int* y = &x;

  FbyRef(     );
  }
```

24

Arrays and Pointers

- Pointers are most often used in function calls and with arrays.
- Because pointers are so often used with arrays, a special pointer has been designated in C to point to the "zeroth" element in an array: **the array name itself!**

25

Arrays & Pointers: Pointer to the "Zeroth" Array Element

Example 2a:

```
float w[128];
float *w_ptr;

w_ptr = & w[0];
```

Example 2b:

```
float w[128];
float *w_ptr;

w_ptr = w;
```

26

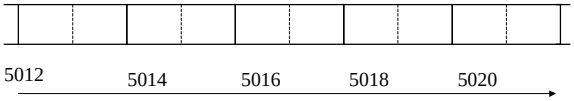
Pointer to the "Zeroth" Array Element: Summary

- Each time you declare an array, you also declare implicitly a pointer to the "zeroth" element!
- The name of this pointer is the name of the array!

27

Arrays: Memory Allocation

```
short x = 2;
short y[4];
y[x] = 12345;
*y = 5121;  //where does y point to?
```

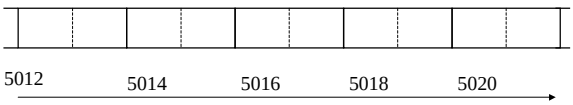


(The memory addresses are arbitrarily chosen)

28

Arrays: Memory Allocation: Pointer Math (1)

```
short x = 2;
short y[4];
y[x] = 12345;
*y = 5121;   //same as: y[0] = 5121;
*(y+1) = 5122;
```

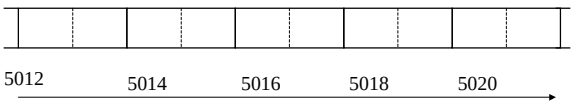


(The memory addresses are arbitrarily chosen)

29

Arrays: Memory Allocation: Pointer Math (2)

```
short x = 2;
short y[4];
*y = 5121;   //same as: y[0] = 5121;
*(y+1) = 5122; //same as: y[1] = 5122;
*(y+x) = 5123; //same as:
```



(The memory addresses are arbitrarily chosen)

30

Arrays: Memory Allocation: Pointer Math (3)

- The following two segments are equivalent statements:

Segment 3a:

```
short x, y[ MAX],
  val;

y[x] = val;
```

Segment 3b:

```
short x, y[ MAX],
  val;

*(y + x) = val;
```

31

Functions, Arrays and Pointers

- When an **array** is **passed** to a **function** it is passed **by REFERENCE**, i.e., **a pointer** to the array is passed!

- Ex:

```
short sAr[ MAX ]; //declare array
SortAr( sAr, MAX ); //call function
```

32

Functions, Arrays and Pointers: Example 3

- A) Write a function that returns the average of an array of type double.
- B) Write a program that uses above function.
- C) Change the program above to account for that the fact that we want to ignore the first 5 data points in the array when calculating the average.

33

Functions, Arrays and Pointers: Example 3 A

```
double Ave( double* dar, int n )
  {
  int i;
  double dtot = 0;
  for( i = 0; i < n ; i++)
     dtot += dar[i];  //pntr. or arr?
  return( dtot/n);
  }
```

34

Functions, Arrays and Pointers: Example 3 B

```
double Ave( double* dar, int n );
main()
  {
  double dAve, dTemp[1000];
  //lines of code to fill array dTemp
  // are omitted here...
  dAve = Ave( dTemp, 1000);
  printf("%d", dAve);
  }
// code for func. Ave() follows here
```

35

Functions, Arrays and Pointers: Example 3 C

```
double Ave( double* dar, int n );
main()
  {
  double dAve, dTemp[1000];
  //lines of code to fill array dTemp
  // are omitted here...
  dAve = Ave( dTemp + 5, 995);
  printf("%d", dAve);
  }
// code for func. Ave() follows here
```

36

Example 4: Function to Sort an Array (1): Problem

- **Assignment:**
- Write a function that sorts the values contained in an array.

37

Example 4: Function to Sort an Array (2): Solution

- Pass arrays whenever possible by reference! (Also, no need for global arrays!)
- Passing an array by value takes a long time (and lots of space) because the computer has to make a copy of the array to pass it to the function.

38

Ex. 4: Function to Sort an Array (3): main

```
#define MAX 10
void SortAr( short *volt, short n );
main(){
  short i, sAr[ MAX ];
  for( i = 0; i < MAX; i++){
     sAr[i] = rand();
     printf("%d %d\n", i, sAr[i] );
     }
  SortAr( sAr, MAX ); // pass by ref
  for( i = 0; i < MAX; i++)
     printf("%d %d\n", i, sAr[i] );
  }
```

39

Ex. 4: Function to Sort an Array (4): Sort Function V1

```
void SortAr( short *volt, short n ){
  short x, y, stemp;
  for( y = 0; y < n - 1; y++){
     for( x = 0; x < n - 1 - y; x++ ){
          if( volt[ x ] > volt[ x + 1] ){
               stemp = volt[x];
               volt[x] = volt[x+1];
               volt[x+1] = stemp;
               }
          }
     }
  }
```

40

Ex. 4: Function to Sort an Array (5): Sort Function V2

```
void SortAr( short *volt, short n ){
  short x, y, stemp;
  for( y = 0; y < n - 1; y++){
     for( x = 0; x < n - 1 - y; x++ ){
          if( *(volt+x)  > *(volt+x+1)){
               stemp = *(volt+x);
               *(volt+x) = *(volt+x+1);
               *(volt+x+1) = stemp;
               }
          }
     }
  }
```

41