Computer Programming & Problem Solving

CS100

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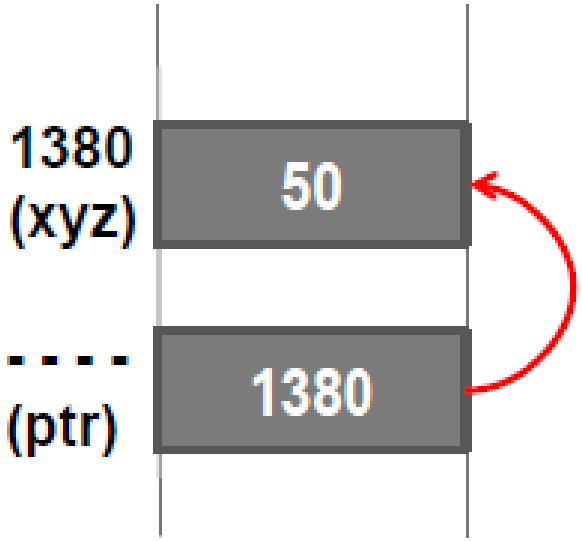
Topics

1. Pointers revisited
2. Arrays and Pointers
3. Passing array elements/whole arrays to functions

Recap of Pointers

1. A pointer is a C variable whose value is the address of another variable.
2. Example:




```
int xyz = 50;

int *ptr; // Here ptr is a pointer to an integer

ptr = &xyz;
```

Pointer to an Array Element

```c
#include <stdio.h>
int main() {
    int a[10] = {10,9,8,7,6,5,4,3,2,1};
    int *i, *j;
    i = &a[3]; //i is pointer to a[3]
    j = &a[7]; //j is pointer to a[3]
    printf("\nAt idx 3, value = %d, address = %u", a[3],&a[3]);
    printf("\nAt idx 3, value = %d, address = %u", a[3], i);
    printf("\nAt idx 7, value = %d, address = %u", a[7], &a[7]);
    printf("\nAt idx 7, value = %d, address = %u", a[7], j);
    return 0;
}
```

1. **What is the address of an array element? Say a[3]?**
2. **So how will I declare a pointer to this array element?**

Base Address of an Array

1. The address of the 1st element of any array, or the address of the element with index = 0.
2. Can be specified using the & operator : eg. &a[0]
3. Also just by mentioning the array name.
4. If we have the base address, we can navigate the whole array.

```c
#include<stdio.h>
int main()
{
int arr[5] = { 1, 2, 3, 4, 5 };
int *ptr = arr; //base address of array arr
int *ptr1 = &arr[0]; //base address of array arr
printf("%p\n", ptr);
printf("%p\n", ptr1);
return 0;
}
```

Output

```
/tmp/SLMyczDl3H.o
0x7fff1ba07c60
0x7fff1ba07c60
```

Recap of Pointers – Illegal usages

1. Pointing at constant.
    a) &235
2. Pointing at array name
    a) int arr[20];
    b) &arr;
3. Pointing at expression
    a) &(a+b)

Pointer Arithmetic

1. **Before we learn about pointers and arrays, we need to learn pointer arithmetic.**

Pointer Operations

1. Addition of a number to a pointer
2. Subtraction of a number from a pointer
3. Subtraction of one pointer from another
4. Comparison of two pointer variables

What happens here?

```
main( )
{
    int  i = 3, *x ;
    float  j = 1.5, *y ;
    char  k = 'c', *z ;

    printf ( "\nValue of i = %d", i ) ;
    printf ( "\nValue of j = %f", j ) ;
    printf ( "\nValue of k = %c", k ) ;
    x = &i ;
    y = &j ;
    z = &k ;
    printf ( "\nOriginal address in x = %u", x ) ;
    printf ( "\nOriginal address in y = %u", y ) ;
    printf ( "\nOriginal address in z = %u", z ) ;
    x++ ;
    y++ ;
    z++ ;
    printf ( "\nNew address in x = %u", x ) ;
    printf ( "\nNew address in y = %u", y ) ;
    printf ( "\nNew address in z = %u", z ) ;
}
```

Value of i = 3
Value of j = 1.500000
Value of k = c
Original address in x = 65524
Original address in y = 65520
Original address in z = 65519
New address in x = 65526
New address in y = 65524
New address in z = 65520

Addition/Subtraction of number to a pointer

```
int i = 4, *j, *k ;
j = &i ;
j = j + 1 ;
j = j + 9 ;
k = j + 3 ;

j = j - 2 ;
j = j - 5 ;
k = j - 6 ;
```

1. **Every time a pointer is incremented/decremented it points to the immediately next/previous <u>location of its type</u>.**

Addition/Subtraction of number to a pointer

```c
#include <stdio.h>
int main() {
    int i=10;
    int * j;
    j = &i;
    printf("\n j = %u", j);
    j++;
    printf("\n j = %u", j);
    j++;
    printf("\n j = %u", j);
    j--;
    printf("\n j = %u", j);
    j=j+9;
    printf("\n j = %u", j);
    j=j-9;
    printf("\n j = %u", j);
    return 0;
}
```

Output

```
/tmp/kUq8tyZUJS.o
j = 3056920588
 j = 3056920592
 j = 3056920596
 j = 3056920592
 j = 3056920628
 j = 3056920592
```

Subtraction of one pointer from another

```
main( )
{
    int  arr[ ] = { 10, 20, 30, 45, 67, 56, 74 } ;
    int  *i, *j ;

    i = &arr[1] ;
    j = &arr[5] ;
    printf ( "%d %d", j - i, *j - *i ) ;
}
```

When possible?

One pointer variable can be subtracted from another provided both variables point to elements of the same array

1. **j – i ?? → 4. why?**
2. **Because j and i are pointing to locations that are 4 integers apart.**
3. ***j – *i ?? → 36.**
4. **Since *j and *i return the values present at addresses contained in the pointers j and i**

Comparison of two Pointer Variables

```
main( )
{
    int  arr[ ] = { 10, 20, 36, 72, 45, 36 } ;
    int  *j, *k ;

    j = &arr [ 4 ] ;
    k = ( arr + 4 ) ;

    if ( j == k )
        printf ( "The two pointers point to the same location" ) ;
    else
        printf ( "The two pointers do not point to the same location" ) ;
}
```

1. **Pointer variables can be compared provided both variables point to objects of the same data type.**

Pointer Operations – Not Allowed

1. Addition of two pointers
2. Multiplication of a pointer with a constant
3. Division of a pointer with a constant

Try and see what errors you get!

How to Access Array Elements – Method 1

```
main( )
{
    int  num[ ] = { 24, 34, 12, 44, 56, 17 } ;
    int  i ;

    for ( i = 0 ; i <= 5 ; i++ )
    {
        printf ( "\naddress = %u ", &num[i] ) ;
        printf ( "element = %d", num[i] ) ;
    }
}
```

1. **Using subscripted variables**

How to Access Array Elements – Method 2

```c
#include <stdio.h>
int main() {
    int A[]={1,2,3,4};
    int i, *j;
    j=&A[0];
    for(i=0;i<6;i++){
        printf("\nIndex = %d",i);
        printf("\nAddress = %u",j);
        printf("\nValue = %d",*j);
        j++;
    }
    return 0;
}
```

1. **Using Pointers**

Base Address of an Array

```c
#include <stdio.h>
int main() {
    int A[]={1,2,3,4};
    int *i, *j, *k; //Pointers to base address
    //Different ways to access base address of an array
    i = &A[0];
    j = A;
    k = (A+0);
    printf("\n Base Address = %u",i);
    printf("\nBase Address = %u",j);
    printf("\nBase Address = %u",k);
    int *l, *m; //Pointers to address of element at index 2
    //Different ways to access address of element at index 2
    l = &A[2];
    m = (A+2);
    printf("\nAddress of element at index 2 = %u",l);
    printf("\nAddress of element at index 2 = %u",m);
    return 0;
}
```

Which method to use?

1. Accessing array elements by pointers is always faster than accessing them by subscripts.
2. Convenience matters:
    a) Array elements should be accessed using pointers if the elements are to be accessed in a fixed order
    b) Access the elements using a subscript if there is no fixed logic in accessing the elements

Passing Array Elements to a Function

1. **Array elements can be passed to a function by calling the function by value, or by reference.**
2. **Call by value: pass values of array elements to the function**
3. **Call by reference: pass addresses of array elements to the function – what is the address of an array element? – Similar to variable addresses.**

Passing Array Elements to a Function

```
main( )
{
      int  i ;
      int  marks[ ] = { 55, 65, 75, 56, 78, 78, 90 } ;

      for ( i = 0 ; i <= 6 ; i++ )
            display ( marks[i] ) ;

       for ( i = 0 ; i <= 6 ; i++ )
            disp ( &marks[i] ) ;
 }
```

```
display ( int  m )
{
      printf ( "%d ", m ) ;
}
```

```
disp ( int  *n )
{
      printf ( "%d ", *n ) ;
}
```

Passing an Entire Array to a Function

```
display ( &num[0], 6 ) ;
display ( num, 6 ) ;
```

1. **Just pass the address of the first (base) element of the array**
2. **And the number of elements in the array**

Passing an Entire Array to a Function

main.c

```c
// Online C compiler to run C program online
#include <stdio.h>
void display ( int *j, int n ) {
    int i ;
    for ( i = 0 ; i <= n - 1 ; i++ ) {
        printf ( "\nelement %d = %d",i, *j ) ;
        j++ ; /* increment pointer to point to next element */ }
}
int main(){
    int num[ ] = { 24, 34, 12, 44, 56, 17 } ;
    display (&num[0], 6 ) ;
    return 0;
}
```

Passing an Entire Array to a Function

```c
// Online C compiler to run C program online
#include <stdio.h>
void display ( int *j, int n ) {
    int i ;
    for ( i = 0 ; i <= n - 1 ; i++ ) {
        printf ( "\nelement %d = %d",i, *j ) ;
        j++ ; /* increment pointer to point to next element */ }
}
int main(){
    int num[ ] = { 24, 34, 12, 44, 56, 17 } ;
    display (num, 6 ) ;
    return 0;
}

```

Passing an Entire Array to a Function

```c
#include <stdio.h>
int search(int array[], int n, int x) {
  for (int i = 0; i < n; i++)
    if (array[i] == x)
      return i;
  return -1;
}
int main() {
  int array[] = {2, 4, 0, 1, 9};
  int x = 1;
  int n = sizeof(array) / sizeof(array[0]);
  int result = search(array, n, x);
  (result == -1) ? printf("Element not found") : printf("Element found at
      index: %d", result);
  return 0;
}
```

Things to remember

```
float  x;
int   *p;
p = &x;
```

1. **Is this correct?**

Things to remember

```
int  *count;
count = 1268;
```

1. **Is this correct?**

Things to remember

```
int  *count;
count = 1268;
```

1. Is this correct?
2. No - Assigning an absolute address to a pointer variable is prohibited

Pointer Expressions

1. If p1 and p2 are two pointers, the following statements are valid:
   a) sum = (*p1) + (*p2); BUT NOT sum = p1 + p2
   b) prod = (*p1) * (*p2);
   c) *p1 = *p1 + 2;
   d) x = *p1 / *p2 + 5;

What is happening here?

```
int x[ 5 ] = { 10, 20, 30, 40, 50 };
int *p;

p = &x[1];
printf( "%d", *p);

p++;
printf( "%d", *p);

p = p + 2;
printf( "%d", *p);
```

Last Slide!

```
int num[ ] = { 24, 34, 12, 44, 56, 17 } ;
```

Base address of an array is given by the name of the array.

So what is *num?

***num and *(num + 0) both refer to 24.**

So what is *(num + 1)

When we say, num[i], the C compiler internally converts it to *(num + i). So following all are same:

```
num[i]
*( num + i )
*( i + num )
i[num]
```