# POINTERS AND ARRAYS

PROGRAMMING LANGUAGES

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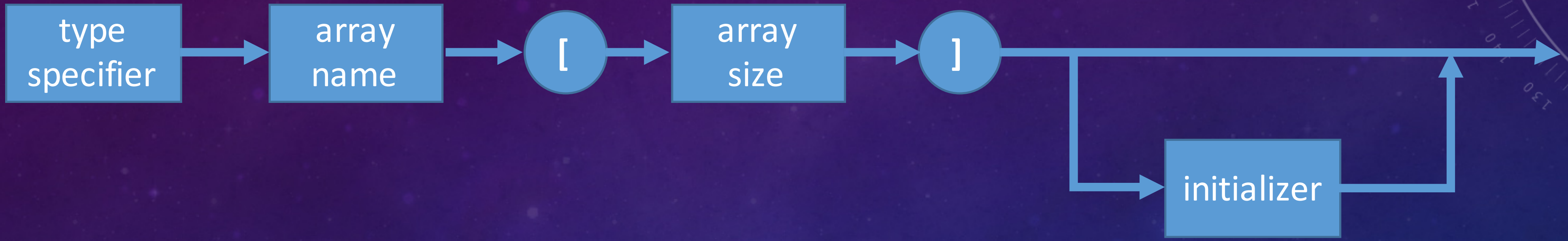
# OUTLINE

- Declaration
- How arrays stored in memory
- Initializing arrays
- Accessing array elements through pointers
- Examples
- Strings
- Multi-dimensional arrays

# DECLARATION



int dailyTemp[365];

dailyTemp[0] = 38;

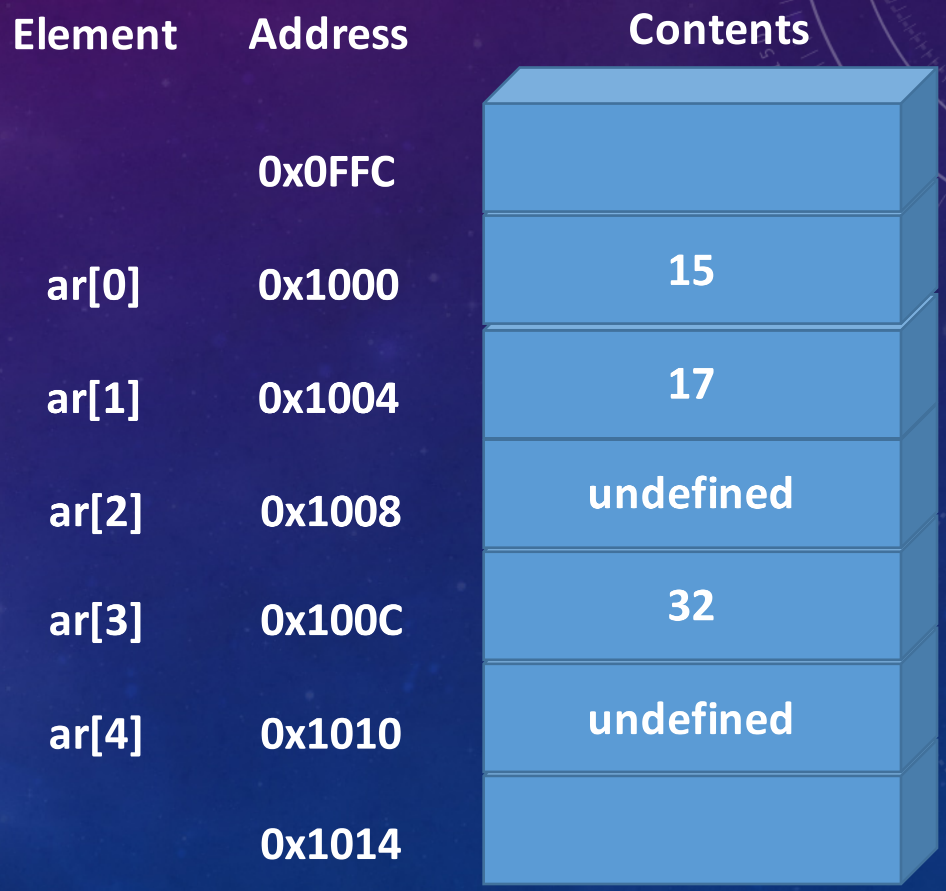
dailyTemp[0] = 23;

- **subscripts begin at 0, not 1 !**

# HOW ARRAYS STORED IN MEMORY

```
int ar[5]; /* declaration */
ar[0] = 15;
ar[1] = 17;
ar[3] = ar[0] + ar[1];
```

- **Note that ar[2] and ar[4] have undefined values!**
  - the contents of these memory locations are whatever left over from the previous program execution



| Element | Address | Contents |
|---|---|---|
| | 0x0FFC | |
| ar[0] | 0x1000 | 15 |
| ar[1] | 0x1004 | 17 |
| ar[2] | 0x1008 | undefined |
| ar[3] | 0x100C | 32 |
| ar[4] | 0x1010 | undefined |
| | 0x1014 | |

# INITIALIZING ARRAYS

- It is incorrect to enter more initialization values than the number of elements in the array
- If you enter fewer initialization values than elements, the remaining elements initialized to zero.
- **Note that 3.5 is converted to the integer value 3!**
- When you enter initial values, you may omit the array size
  - the compiler automatically figures out how many elements are in the array...

```
int a_ar[5];
int b_ar[5] = {1, 2, 3.5, 4, 5};
int c_ar[5] = {1, 2, 3};

char d_ar[] = {‘a’, ‘b’, ‘c’, ‘d’};
```

# ACCESSING ARRAY ELEMENTS THROUGH POINTERS

short ar[4];

short *p;

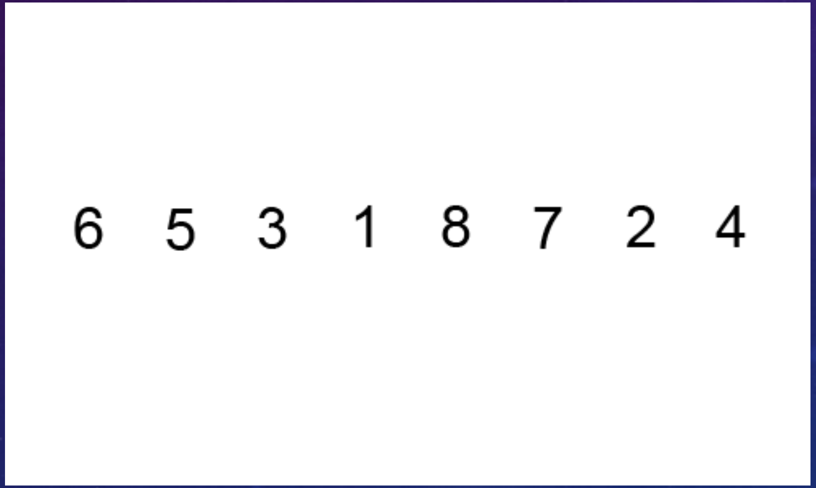
p = & ar[0]; // assigns the address of array element 0 to p.

- p = ar; **is same as above assignment!**
- *(p+3) refers to the same memory content as ar[3]

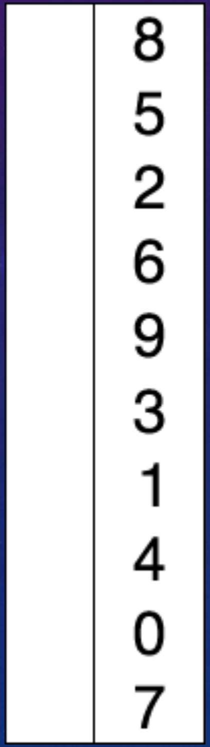
```
float ar[5], *p;
------------------------------------------------------------------
p = ar ;            // legal
ar = p;             // illegal
&p = ar;            // illegal
ar++;               // illegal
ar[1] = *(p+3);     // legal
p++;                // legal
```

# EXAMPLES

- Bubble sort



- Selection sort



# STRINGS

- A string is an array of characters terminated by a null character.
  - **null character is a character with a numeric value of 0**
  - it is represented in C by the escape sequence '\0'
- A string constant is any series of characters enclosed in double quotes
  - it has datatype of array of char and each character in the string takes up one byte!

- char str[] = "some text";
- char str[10] = "yes";
- **char str[3] = "four"**
- **char str[4] = "four"**

- char *ptr = "more text" ;

# STRING ASSIGNMENTS

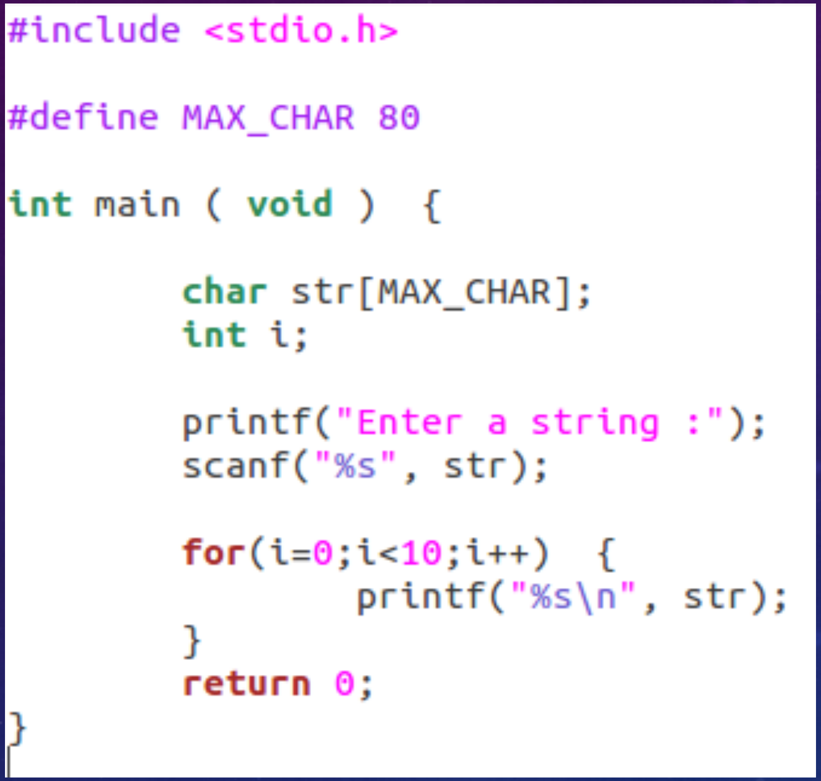
```
main () {
        char array[10];
        char *ptr=“10 spaces”;
        char *ptr2;
        array = “not OK”;                 // can NOT assign to an address !
        array[5] = ‘A’;                   // OK
        ptr1[5] = ‘B’;                    // OK
        ptr1=“OK”;
        ptr1[5]=‘C’;                      // questionable due to the prior assignment
        *ptr2 = “not OK”;                 // type mismatch
        ptr2=“OK”;
}
```

# STRINGS VS. CHARS

```
char ch = ‘a’;   // one byte is allocated for ‘a’
*p = ‘a’;        // OK
p = ‘a’;         // Illegal
```

```
char *p = “a”;  // two bytes allocated for “a”
*p = “a”;       // INCORRECT
p = “a”;        // OK
```

# READING & WRITING STRINGS

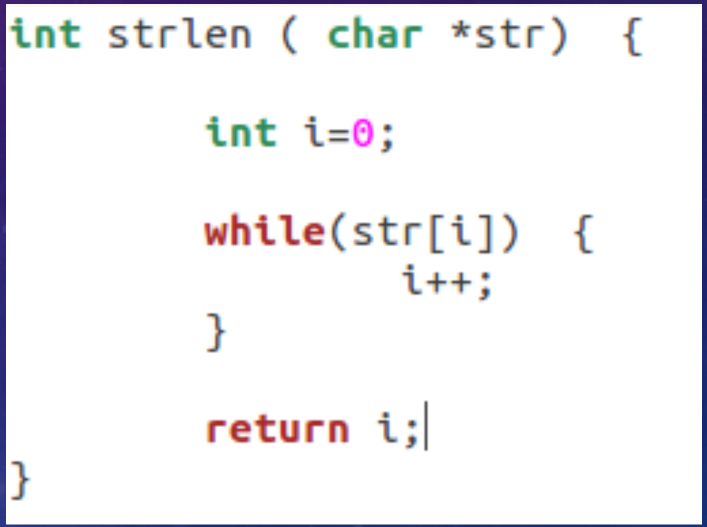


```
#include <stdio.h>

#define MAX_CHAR 80

int main ( void )  {

        char str[MAX_CHAR];
        int i;

        printf("Enter a string :");
        scanf("%s", str);

        for(i=0;i<10;i++)  {
                printf("%s\n", str);
        }
        return 0;
}
```

- You can read strings with *scanf()* function.
    - the data argument should be a pointer to an array of characters ***that is long enough to store*** the input string.
    - after reading input characters scanf() automatically appends a null character to make it a proper string
- You can write strings with *printf()* function.
    - the data argument should be a pointer to a null terminated array of characters

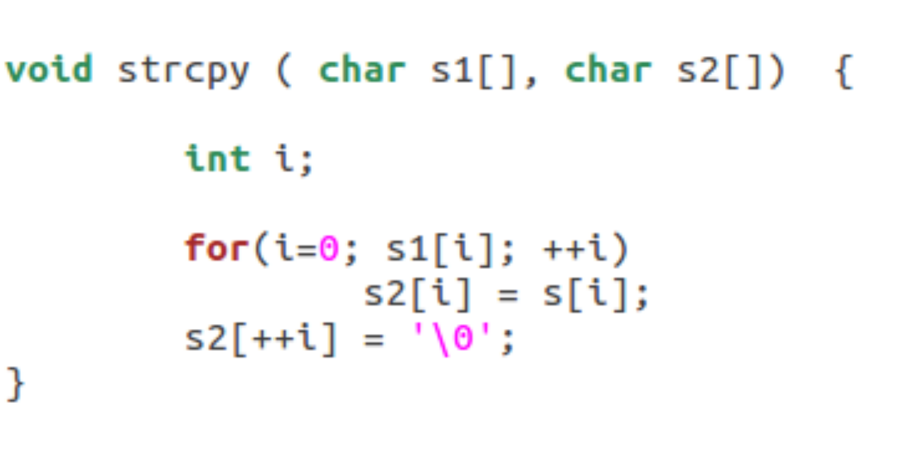
# STRING LENGTH FUNCTION

- We test each element of array, one by one, until we reach the null character.
  - it has a value of zero, making the while condition **false**
  - any other value of str[i] makes the while condition **true**
  - once the null character is reached, we exit the while loop and return *i*, which is the last subscript value

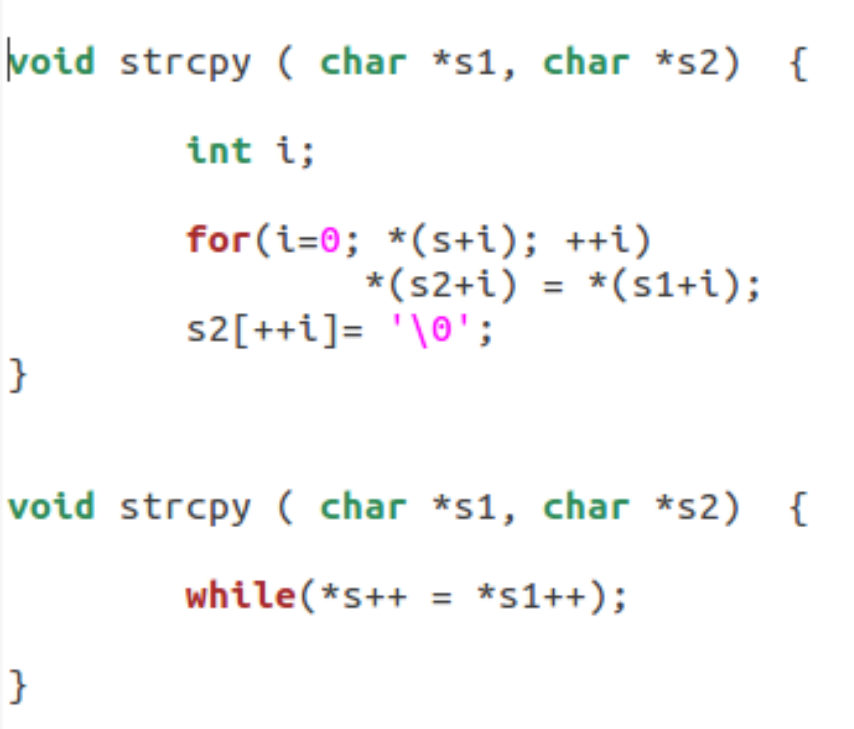


```
int strlen ( char *str)  {

        int i=0;

        while(str[i])  {
                i++;
        }

        return i;
}
```

# STRING COPY FUNCTION



```
void strcpy ( char s1[], char s2[])  {

        int i;

        for(i=0; s1[i]; ++i)
                s2[i] = s[i];
        s2[++i] = '\0';
}
```



```
void strcpy ( char *s1, char *s2)  {

        int i;

        for(i=0; *(s+i); ++i)
                *(s2+i) = *(s1+i);
        s2[++i]= '\0';
}


void strcpy ( char *s1, char *s2)  {

        while(*s++ = *s1++);

}
```

# OTHER STRING FUNCTIONS

- strcpy()
- strncpy()
- strcat()
- strncat()
- strcmp()
- strncmp()
- strchr()
- strcspn()
- strpbrk()
- strrchr()
- strspn()
- strstr()
- strtok()
- strerror()
- strlen()
- …

# PATTERN MATCHING EXAMPLE

- Write a program that
    - gets two strings from the user
    - search the first string for an occurrence of the second string
    - if it is successful
        - return byte position of the occurence
    - otherwise
        - return -1

# MULTI-DIMENSIONAL ARRAYS

- In the following, ar is a 3-element array of 5-element arrays

  int ar[3][5];

- In the following, x is a 3-element array of 4-elemet arrays of 5-element arrays

  char x[3][4][5];

- the array reference

  ar[1][2]

- is interpreted as

  *(ar[1]+2)

- which is further expanded to

  *(*(ar+1)+2)

# INITIALIZATION OF MULTI-DIMENSIONAL ARRAYS

```
int exap[5][3] = { {  1, 2, 3 },
                     { 4 },
                     { 5, 6, 7 } };
```

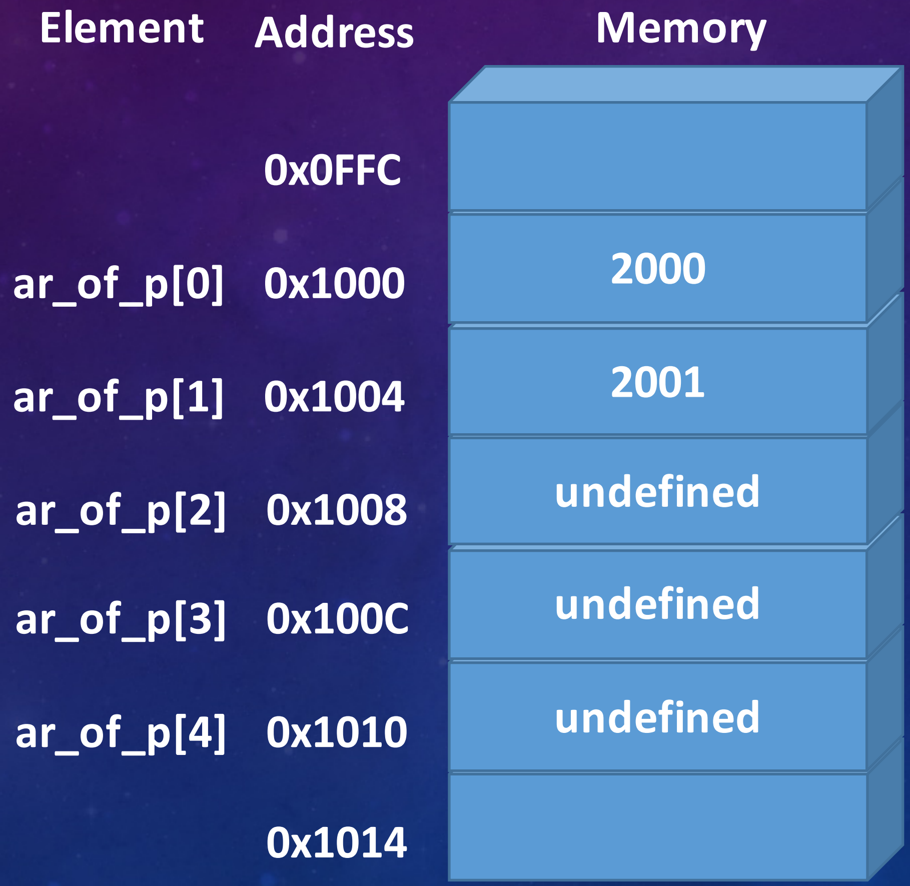
```
1     2     3
4     0     0
5     6     7
0     0     0
0     0     0
```

```
int exap[5][3] = {  1, 2, 3,
                     4,
                    5, 6, 7 };
```

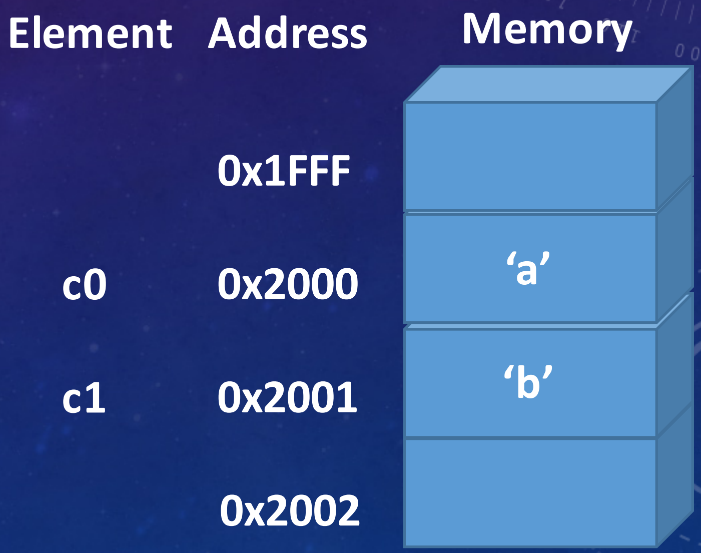
```
 1    2     3
4     5     6
7     0     0
0     0     0
0     0     0
```

# ARRAY OF POINTERS

```
char *ar_of_p[5];
char c0 = ‘a’;
char c1 = ‘b’;

ar_of_p[0] = &c0;
ar_of_p[1] = &c1;
```



| Element | Address | Memory |
|---|---|---|
| | 0x0FFC | |
| ar_of_p[0] | 0x1000 | 2000 |
| ar_of_p[1] | 0x1004 | 2001 |
| ar_of_p[2] | 0x1008 | undefined |
| ar_of_p[3] | 0x100C | undefined |
| ar_of_p[4] | 0x1010 | undefined |
| | 0x1014 | |



| Element | Address | Memory |
|---|---|---|
| | 0x1FFF | |
| c0 | 0x2000 | ‘a’ |
| c1 | 0x2001 | ‘b’ |
| | 0x2002 | |

# POINTERS TO POINTERS

| | |
|---|---|
| int r = 5; | declares ***r*** to be an int |
| int *q = &r; | declares ***q*** to be a pointer to an int |
| int **p = &q; | declares ***p*** to be a pointer to a pointer to an int |
| | |
| r = 10; | Direct assignment |
| *q = 10; | Assignment with one indirection |
| **p = 10; | Assignment with two indirections |