CHARACTER PROCESSING AND STRINGS

The Data Type *char*

- Each character is stored in a machine in one byte (8 bits)
  - 1 byte is capable of storing 2^8 or 256 distinct values.
- When a character is stored in a byte, the contents of that byte can be thought of as either a character or as an integer.

The Data Type *char*

- A character constant is written between single quotes.

  ‘a’

  ‘b’

- A declaration for a variable of type char is

  char c;

- Character variables can be initialized

  char c1=‘A’, c2=‘B’, c3=‘*’;

In C, a character is considered to have the integer value corresponding to its ASCII encoding.

lowercase	‘a’	‘b’	‘c’	...	‘z’
ASCII value	97	98	99	...	122
uppercase	‘A’	‘B’	‘C’	...	‘Z’
ASCII value	65	66	67		90
digit	‘0’	‘1’	‘2’	...	‘9’
ASCII value	48	49	50	...	57
other	‘&’	‘*’	‘+’	...	
ASCII value	38	42	43		

Characters and Integers

- There is no relationship between the character ‘2’ (which has the ASCII value 50) and the constant number 2.
- ‘2’ is not 2.
- ‘A’ to ‘Z’ 65 to 90
- ‘a’ to ‘z’ 97 to 112
- Examples:
  - printf(“%c”,’a’);
  - printf(“%c”,97); have similar output.
  - Printf(“%d”,’a’);
  - printf(“%d”,97); have also similar output.

The Data Type *char*

- Some nonprinting and hard-to-print characters require an escape sequence.
- For example, the newline character is written as **\n** and it represents a single ASCII character.

Name of character	Written in C	Integer Value
alert	\a	7
backslash	\\	92
double quote	\”	34
horizontal tab	\t	9

Input and Output of Characters

- **getchar ()** reads a character from the keyboard.

```
c = getchar(); /* variable c contains the
                  next character of input */
```

- **putchar ():** prints a character to the screen.

```
putchar(c);    /* prints the contents of the
                  variable c as a character */
```

```c
/* Illustrating the use of getchar( ) and putchar( ) */

#include <stdio.h>
int main (void)
{
   char c;
   while ((c=getchar()) != EOF) {
      putchar(c);
      putchar(c);
   }
}
```

```
abcdef
aabbccddeeff
```

EOF : It is control-d in Unix; control-z in DOS.

```
/* Capitalize lowercase letters and
 * double space */

int main(void)
{  int c;
   while ((c=getchar()) != EOF){
      if ('a' <= c && c <= 'z')
         putchar(c+'A'-'a'); /*convert to
uppercase*/
     else if (c == '\n'){
         putchar ('\n');
         putchar ('\n');
     }
     else putchar (c);
   }
}
```

cop3223!c C

Character Functions

Function	Nonzero (true) is returned if
`isalpha(c)`	c is a letter
`isupper(c)`	c is an uppercase letter
`islower(c)`	c is a lowercase letter
`isdigit(c)`	c is a digit
`isalnum(c)`	c is a letter or digit
`isspace(c)`	c is a white space character

Function	Effect
`toupper(c)`	changes c to uppercase
`tolower(c)`	changes c to lowercase
`toascii(c)`	changes c to ASCII code

```c
/* Capitalize lowercase letters and double space */
#include <stdio.h>
#include<ctype.h>

int main(void)
{  int c;
   while ((c=getchar()) != EOF){
      if (islower(c))
         putchar(toupper(c)); /*convert to uppercase */
      else if (c == '\n'){
         putchar ('\n');
         putchar ('\n');
      }
      else  putchar (c);
   }
}
```

STRINGS

Fundamentals of Strings and Characters

- **Characters**
  - Building blocks of programs
    - Every program is a sequence of meaningfully grouped characters
  - Character constant
    - An **`int`** value represented as a character in single quotes
    - **`'z'`** represents the integer value of **`z`**
- **Strings**
  - Series of characters treated as a single unit
    - Can include letters, digits and special characters (**`*`**, **`/`**, **`$`**)
  - String literal (string constant) - written in double quotes
    - **`"Hello"`**
  - Strings are arrays of characters in C
    - String is a pointer to first character
    - Value of string is the address of first character

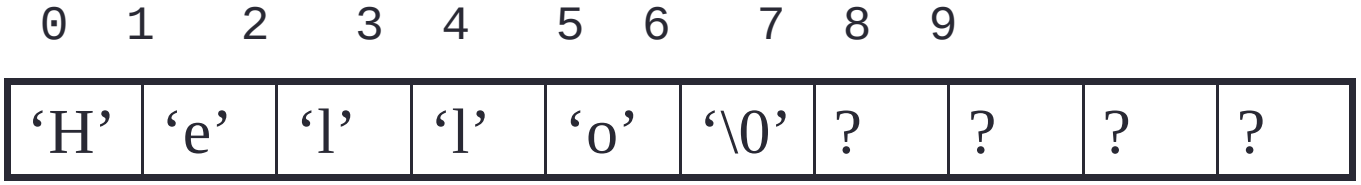
Strings

- A string constant such as “a string” is an array of characters.
- Each element of the array stores a character of the string.
- In its internal representation, the array is terminated with the null character ‘\0’ so that the end of the string can be found easily.
- Thus, the length of the array is defined one more than the number of characters between the double quotes.

Declaring Strings

```
char myString[10];

myString[0] = ‘H’;
myString[1] = ‘e’;
myString[2] = ‘l’;
myString[3] = ‘l’;
myString[4] = ‘o’;
myString[5] = ‘\0’;
```



Initializing Strings

- Character arrays can be initialized when they are declared :

```
char name[5] ={‘M’,’E’, ‘T’,’U’,’\0’};
char name[5] = “METU”; /*compiler
                automatically adds ‘\0’ */
char name[] = “METU”; /*compiler calculates
                the size of the array */
```

Strings and Pointers

- We can declare and initialize a string as a variable of type **`char *`**

```
char *color = “blue”;
```

- But the interpretation is different. “blue” is stored in memory as a string constant. The variable `color` is assigned the address of the constant string in memory.
- If we declare it as:

```
char c[] = “blue”;
```

the array `c` contains the individual characters followed by the null character.

Inputting Strings

- Using subscripts:

```
char c, name[20];
int i;
for (i = 0; (c = getchar())!=‘\n’; i ++)
  name[i] = c;
name[i]=‘\0’;
```

- Using scanf and %s format:

```
scanf(“%s”, name);
```

  - no need to use & operator
  - it will skip the leading blanks in the input, then characters will be read in. The process stops when a white space or EOF is encountered.
  - Remember to leave room in the array for **`'\0'`**

Printing Strings

- Using %s format:

```
printf(“%s %s\n”, “Nice to meet you”, name);
```

- Using subscripts: e.g. printing name backwards

```
for (--i; i>=0; --i)
  putchar(name[i]);
putchar(‘\n’);
```

Examples

- `printf("***Name:%8s*Lastname:%3s*** \n",“John", “Smith");`
- Output:

```
***Name:    John*Lastname:Smith***
```

- `printf("***%-10s*** \n", “John");`
- Output

```
***John      ***
```

- `scanf("%d%s%d%s", &day,month,&year,day_name);`
- Example input:

```
     5          November 2001      Monday
```

String Handling Functions (`string.h`)

- String handling library has functions to
  - Manipulate string data
  - Search strings
  - Tokenize strings
  - Determine string length

Function prototype	Function description
`char *strcpy( char *s1, char *s2 )`	Copies string **s2** into array **s1**. The value of **s1** is returned.
`char *strncpy( char *s1, char *s2, int n )`	Copies at most **n** characters of string **s2** into array **s1**. The value of **s1** is returned.
`char *strcat( char *s1, char *s2 )`	Appends string **s2** to array **s1**. The first character of **s2** overwrites the terminating null character of **s1**. The value of **s1** is returned.
`char *strncat( char *s1, char *s2, int n )`	Appends at most **n** characters of string **s2** to array **s1**. The first character of **s2** overwrites the terminating null character of **s1**. The value of **s1** is returned.

String Handling Functions (cont.)

- **`unsigned strlen(char *s);`**
  - A count of the number of characters before \0 is returned.
- **`int strcmp(char *s1, char *s2 );`**
  - Compares string **`s1`** to **`s2`**
  - Returns a negative number if **`s1 < s2`**, zero if **`s1 == s2`** or a positive number if **`s1 > s2`**
- **`int strncmp(char *s1, char *s2, int n );`**
  - Compares up to **`n`** characters of string **`s1`** to **`s2`**
  - Returns values as above

strcpy() and strncpy()

- We cannot change the contents of a string by an assignment statement.

```
char str[10];
str = “test”;  /*Error! Attempt to change the base
                address*/
```

- Thus, we need to use string copy functions
  - `strcpy(str, “test”); /*contents of str changed*/`
  - `strncpy(str, “testing”, 5);`

    ```
    str[5] =‘\0’;  /* str contains “testi” only */
    ```
  - `strcpy(str, “a very long string"); /*overflow of array boundary */`

strcat() and strncat()

```
char s[8]=“abcd”;
strcat(s,”FGH”);   // s keeps abcdFGH

char t[10]=“abcdef”;
strcat(t,”GHIJKLM”);  //exceeds string length!

strncat(t, "GHIJKLM",3);
t[9] = '\0';      // t keeps abcdefGHI
```

`strcmp()` and `strncmp()`

- We can compare characters with <,>,<= etc.

  e.g. `'A' < 'B'`

- But we cannot compare strings with the relational operators.

  e.g. `str1 < str2` will compare the memory addresses pointed by `str1` and `str2`.

- Therefore we need to use string comparison functions.

```
strcmp("abcd", "abcde") ->returns a negative number
strcmp("xyz", "xyz")    -> returns zero
strcmp("xyz", "abc")    -> positive number
strncmp("abcde", "abcDEF", 3) -> zero
strncmp("abcde", "abcDEF", 4) -> positive number
```

Examples

```
char s1[] = “beautiful big sky country”;
char s2[] = “how now brown cow”;
```

Expression	Value
strlen(s1)	25
strlen(s2+8)	9

Statements	What is printed
printf(“%s”, s1+10);	big sky country
strcpy(s1+10, s2+8)	
strcat(s1, “s!”);	
printf(“%s”,s1);	beautiful brown cows!

```
#include <stdio.h>
#include <string.h>
#define LENGTH 20
/* A string is a palindrome if it reads the same backwards and
  forwards. e.g. abba, mum, radar. This programs checks whether a
  given string is palindrome or not.

int isPalindrome(char s[]);  // function prototype
int main()
{
    char str[LENGTH];

    // read the string
    printf(“Enter a string ");
    scanf("%s", str);

    // Check if it is a palindrome.
    if (isPalindrome(str))
       printf("%s is a palindrome.\n", str);
    else
       printf("%s is not a palindrome.\n", str);
 }
```

```
int isPalindrome(char str[])
{
    int i, j, flag;

    i = 0;                      // index of the first character
    j = strlen(str) - 1;        // index of the last character
    flag = 1;                   //assume it is a palindrome
    while ((i<j) && flag){
                          // compare the ith and jth. characters
       if (str[i] != str[j])
          flag = 0;  // if not same then string cannot be a
                        //palindrome.
       else {
          i++;
          j--;
       }        // advance to next characters
    }
    return flag;
}
```

```
#include <stdio.h>
#include <string.h>

#define LENGTH 20

 // This program converts a positive integer to a binary
 // number which is represented as a string. For instance
 // decimal number 12 is 1100 in binary system.

void toBinary(int decVal, char *);  //function prototype
int main()
{
    int num;
    char bin[LENGTH];

    // read a positive integer
    printf(“Enter a number: ");
    scanf("%d",&num);

    // Convert the number and print it.
    toBinary(num, bin);
    printf(“Binary equivalent of %d is : %s",num,
            bin);
}
```

```
void toBinary(int decVal, char *sb) {

    char s0[LENGTH], s1[LENGTH];

    // create an empty string.
    strcpy(sb,"");
    if (decVal == 0)
       strcat(sb,"0");  // if number is zero result is 0
    else                // otherwise convert it to binary
       while (decVal != 0) {
          strcpy(s0,"0");
          strcpy(s1,"1");
          if (decVal%2 == 0)
             strcpy(sb,strcat(s0,sb)); //last character is 0
          else
             strcpy(sb,strcat(s1,sb));  //last character is 1
          decVal = decVal / 2;  /* advance to find the next digit */
       }
    return sb;
}
```