Programming with String

A string of Characters

A string of characters is a sequence of data of type `char` (the ASCII codes) stored in consecutive memory loactions and terminated by the null character '\0' (the ASCII value is 0). The null string (of length zero (0)) is the null character only.

An Example ···

A string constant is written within a pair of double quotes. Consider the string “`IIT Kharagpur`”. It is stored as:

0													13	
I	I	T		K	h	a	r	a	g	p	u	r	\0	···
73	73	84	32	···									0	···

The length of this string is 13 [$0\cdots 13$].

Character Array

An 1-D array of type `char` is used to store a string.

Initialization of String

```
#include <stdio.h>
#define MAXLEN 100
int main() // stringInit.c
{
    char a[MAXLEN]={'B','i','g',' ',
                    'B','a','n','g','\0'},
         b[MAXLEN]="Black Hole",
         c[]="Quantum Gravity",
         *cP="Super String" ;
    printf("a: %s\nb: %s\nc: %s\n*cP: %s\n",
            a, b, c, cP) ;
    printf("a[0] = %c, b[1] = %c, c[2] = %c, cP[3
            a[0], b[1], c[2], cP[3]) ;
    return 0;
}
```

Output

```
$ cc -Wall stringInit.c
$ a.out
a:   Big Bang
b:   Black Hole
c:   Quantum Gravity
*cP: Super String
a[0] = B, b[1] = l, c[2] = a, cP[3] = e
```

Note

- All constant strings are stored in the read-only memory.
- Space is allocated for `a[], b[], c[]` to store the strings. But the pointer `cP` directly points to the begining of the string in the read-only memory. Any attempt to change that location results in segmentation violation in GCC.

Initialization of String

```
#include <stdio.h>
#define MAXLEN 100
int main() // stringInit1.c
{
    char a[MAXLEN]={’B’,’i’,’g’,’ ’,
                    ’B’,’a’,’n’,’g’,’\0’},
         b[MAXLEN]="Black Hole",
         c[]="Quantum Gravity",
         *cP="Super String" ;
    a[0] = ’A’, b[0] = ’A’, c[0] = ’A’ ;
    cP[0] = ’A’ ;  // segmentation fault
    return 0;
}
```

Reading a String

The library function `scanf()` can be used to read a string. The format conversion specifier for a sequence of non-white-space characters is `%s`.

```
#include <stdio.h>
#define MAXLEN 100
int main() // stringRead1.c
{
    char a[MAXLEN], b[MAXLEN], c[MAXLEN] ;

    printf("Enter the 1st string of char\n");
    scanf("%s",a); printf("a: %s\n",a);
    printf("Enter the 2nd string of char\n");
    scanf("%[^\n]",b); printf("b: %s\n",b);
    printf("Enter the 3rd string of char\n");
    scanf(" %[^\n]",c); printf("c: %s\n",c);
    return 0;
}
```

Output

```
$ cc -Wall stringRead1.c
$ a.out
Enter the 1st string of char
The world is made of facts
a:  The
Enter the 2nd string of char
b:  world is made of facts
Enter the 3rd string of char
and not of matter.
c:  and not of matter.
```

Problem Solving

Write a non-recursive function that will take a character string as a parameter and will return its length. Also write a recursive function to do the same job.

Inductive Definition: length

$$\mathrm{length}(s) = \begin{cases} 0 & \text{if } s = \mathrm{null}, \\ 1 + \mathrm{length}(\mathrm{tail}(s)) & \text{otherwise.} \end{cases}$$

The tail(s) is the string after removal of the 0^{th} character of s.

Non-recursive length()

```
int length(char *s) {
    int len=0;

    while(s[len]) ++len ;
    return len;
} // lengthI.c
```

Recursive length()

```
#define NIL (’\0’)
int length(char *s) {
    if(s[0] == NIL) return 0;
    return 1 + length(s+1);
} // lengthR.c
```

string.h

Library functions (libc) are available to manipulate strings. The prototypes of these functions are available in the header file string.h. The function `size_t strlen(const char *s);` returns the length of the string. Note that the character string pointed by s cannot be changed (const).

strlen()

```
#include <stdio.h>
#include <string.h>
#define MAXLEN 100
int length(char *);
int main() // lengthL.c
{
    char b[MAXLEN] ;
    printf("Enter a string of char\n") ;
    scanf("%[^\n]", b) ;
    printf("length(%s) = %d\n",b,strlen(b));
    return 0;
} // lengthL.c
```

Problem Solving

Write a non-recursive and a recursive program that copies a string to another array. We assume that the target array has sufficient space. The function returns the number of character copied.

Non-recursive Function

```
#define NIL ('\0')
int strCopy(char *dst, const char *src){
    int count=-1;
    do{
       ++count ;
       dst[count] = src[count];
    } while(src[count] != NIL);
    return count ;
} // stringCopyI.c
```

Recursive Function

```
#define NIL (’\0’)
int strCopy(char *dst, const char *src){
    dst[0] = src[0] ;
    if(src[0] == NULL) return 0 ;
    return strCopy(src+1, dst+1) + 1 ;
} // stringCopyR.c
```

strcpy()

The function `char *strcpy(char *dest, const char *src);` copies the source string to the destination string. It also returns the destination string pointer.

Problem Solving

Write a non-recursive C Function that will concatenate a string to the end of another string. As an example, let `s:"IIT "` and `ct:"Bhubaneswar"`. After the concatenation `s:"IIT Bhubaneswar"`.

Non-recursive Function

```
#define NIL (’\0’)
int concat(char *dst, const char *sec){
    int count=0, i=0;
    while(dst[count] != NIL) ++count;
    do dst[count++] = sec[i];
    while(sec[i++] != NIL);
    return count-1;
} // concatI.c
```

strcat()

The function `char *strcat(char *dest, const char *src);` concatenates the source string to the destination string. It also returns the destination string pointer.

Problem Solving

Write a non-recursive and a recursive C Function that will compare two strings `s1` and `s2`. It returns < 0 if `s1` $<$ `s2`, 0 if `s1` $=$ `s2`, or > 0 if `s1` $>$ `s2`.

Non-recursive Function

```
#define NIL ('\0')
int strComp(const char *s1, const char *s2){
    int i=0;

    while(s1[i]==s2[i] && s1[i] != NIL
                       && s2[i] != NIL) ++i;
    if(s1[i] == s2[i]) return 0;
    return (int)(s1[i] - s2[i]);
} // strCompI.c
```

Problem Solving

Write a non-recursive and a recursive C Function that will test whether a pattern string is the prefix of a text string. As an example "IIT" is a prefix of "IIT Kanpur", but "IIIT" is not.

Inductive definition

$$\text{prefix}(p,t) = \begin{cases} \text{true}, & \text{if } p = \text{Nil} \\ \text{false}, & \text{if } p \neq \text{Nil and } t = \text{Nil} \\ \text{false}, & \text{if head}(p) \neq \text{head}(t) \\ \text{prefix}(\text{tail}(p), \text{tail}(t)), & \\ & \text{if head}(p) = \text{head}(t) \end{cases}$$

Steps

A pattern p of length m is a prefix of a text t of length n, if $m \leq n$ and $p[0 \cdots m-1]$ is same as $t[0 \cdots m-1]$.

Non-recursive Function

```
#define TRUE 1
#define FALSE 0
static int length(const char *) ;
int isPrefix(const char *t, const char *p) {
    int m = length(p), n = length(t), i;

    if(m > n) return FALSE ;
    for(i=0; i<m; ++i)
        if(p[i] != t[i]) return FALSE;
    return TRUE;
} // isPrefixI.c
static int length(const char *s) {
    int len=0;

    while(s[len]) ++len ;
    return len;
}
```

Recursive Function

```
#define TRUE 1
#define FALSE 0
#define NIL ('\0')
int isPrefix(const char *t, const char *p) {
    if(*p == NIL) return TRUE;
    if(*p != *t) return  FALSE;
    return isPrefix(t+1, p+1);
} // isPrefixR.c
```

Problem Solving

Write a non-recursive C Function that tests whether a pattern string is a substring of a text string. The function returns -1 if the pattern is not a substring, otherwise it returns the index of the starting position (first occurrence) of the pattern in the text.
Similarly write a recursive C function.

Non-recursive C Function

```
#define NIL ('\0')
int isSubString(const char *t, const char *p){
    int index = 0;
    const char *pP, *tP ;

    while (*t != NIL) { // p cannot be a substring
        tP = t ;
        pP = p ;
        do {
            if(*pP == NIL) return index ; // p is a substri
            if(*tP == NIL) return NOTSUBSTR ;
                                          // p cannot be a
        } while (*pP++ == *tP++);         // test next char
        ++index ;
        ++t ;                             // shift in text
    }
    return NOTSUBSTR ;
} // subStringI.c
```

Recursive C Function

```
#define NIL ('\0')
#define TRUE 1
#define FALSE 0
int isSubString(const char *t, const char *p){
    int n ;

    if(length(t) < length(p)) return -1 ;
    if(isPrefix(t, p)) return 0 ;
    n = isSubString(t+1, p) ;
    if(n == -1) return -1 ;
    else return n + 1 ;
} // subStringR.c
```

`strstr()`

The library function `char *strstr(const char *t, const char *p);` This function finds the first occurrence of the substring `p` in the string `t`.

Problem Solving

Write a non-recursive function that will left-shift a non-null string. A null string will remain as it is.

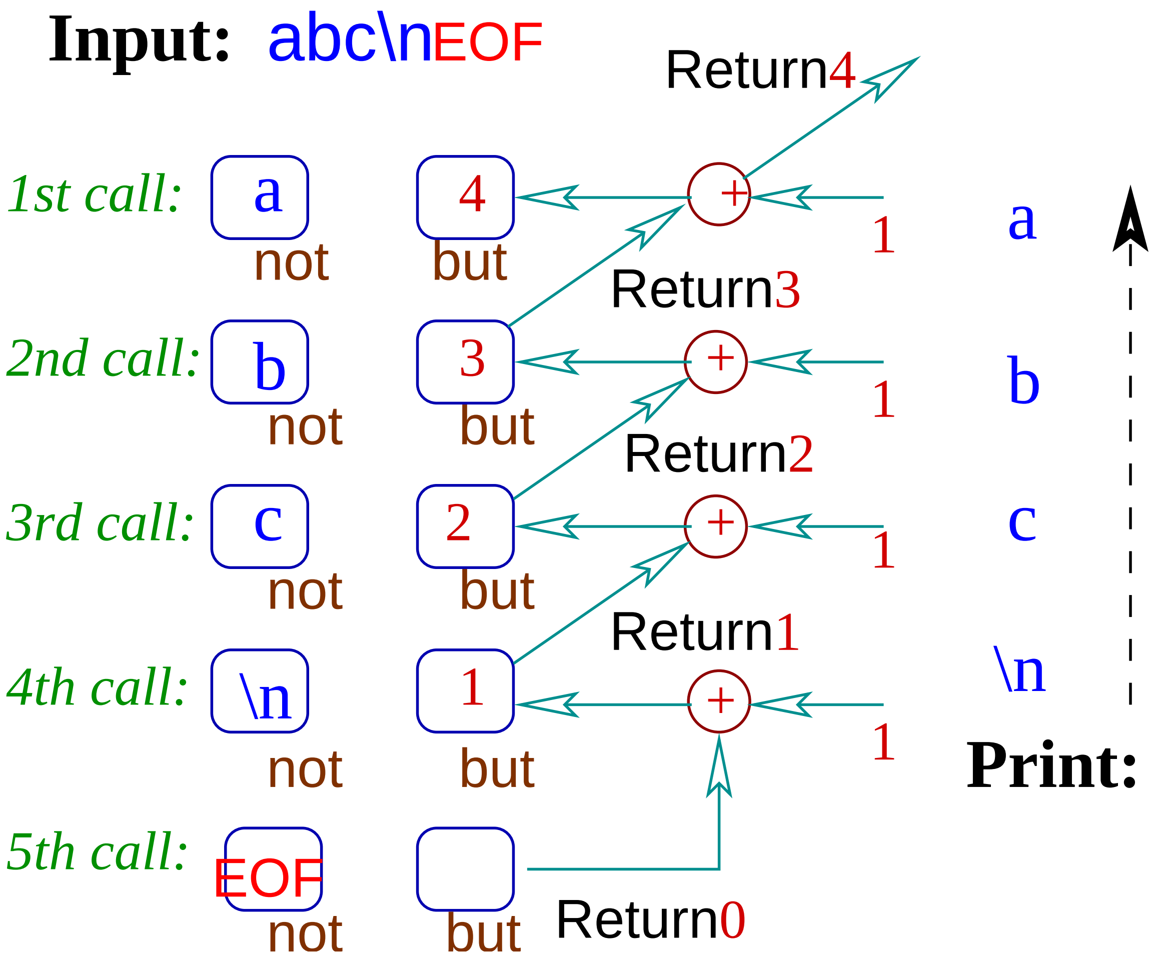
Write a recursive function to solve this problem.

what()

What does the following function do?

```
int what() {
    char not ;
    int but ;

    if((not = getchar()) == EOF) return 0 ;
    but = what() + 1 ;
    putchar(not) ;
    return but ;
} // printReverse1.c
```



Input: abc\nEOF

1st call: a not 4 but

2nd call: b not 3 but

3rd call: c not 2 but

4th call: \n not 1 but

5th call: EOF not but

Return0

Return1

Return2

Return3

Return4

1 1 1 1

a

b

c

\n

Print: