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EEEE1042 - Lecture 5
Strings, functions
Autumn Semester 2021.

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University of Nottingham Malaysia
Department of Electrical and Electronic Engineering

EEEE1042 C++ Programming: Scheduled classes

EEEE1042: for EE students, EEEE1032: for Mecha students.

			EEEE1042	EEEE1032	
Week	Dates	Lecture	Practical	Practical	Assessment
4	Sep 26 – 30	Thu2-4pm			
5	Oct 3 – 09	Thu2-4pm	Mon3-6pm	Wed3-6pm	
6	Oct 10 – 14	Thu2-4pm	P.H.	Wed3-6pm	
7	Oct 17 – 21	Thu2-4pm	Mon3-6pm	Wed3-6pm	PT1 5%
8	Oct 24 – 28	Thu2-4pm	P.H.	Wed3-6pm	
9	Oct 31 –Nov 04	Project Week 1			
10	Nov 07 – 11	Thu2-4pm	Mon3-6pm	Wed3-6pm	PT2 5%
11	Nov 14 – 18	Thu2-4pm	Mon3-6pm	Wed3-6pm	CW1 10%
12	Nov 21 – 25	Project Week 2			
13	Nov 28 –Dec 04	Thu2-4pm	Mon3-6pm	Wed3-6pm	PT3 5%
14	Dec 05 – 09	Project Week 3			
15	Dec 12 – 16	Thu2-4pm	P.H.	Wed3-6pm	PT4 5%
16	Dec 19 – 23	Study Week			CW2 30%
17-18	Dec 26 – Jan 06	Study Weeks			
19-20	Jan 09 – 21	Final Exam (40%)			

Outline EEEE1042 C Lecture 5:

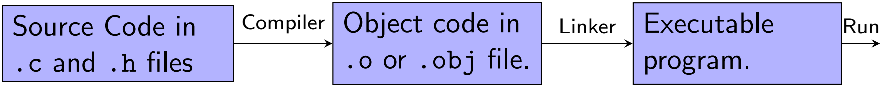
1. Functions
   - Call by value vs call by reference
   - Recursion
2. Generating Random Numbers
3. String functions in C
   - Strings Chars and Pointers
   - C string library

Function declarations and definitions

Three main parts of the program

1. Function declarations ⇒ at beginning or in header files.
2. Main body ⇒ in the main c/cpp file.
3. Function definitions ⇒ at end or own function file.

```c
#include <stdio.h>
int printAndAdd (int , int ); // function declaration
int main () {
    int x;
    x=printAndAdd(3,6); // function call
    return 0;
}
int printAndAdd (int x, int y) { // function definition
    int z=x+y;
    printf("In function printAndAdd: x+y=%d\n",z);
    return(z);
}
```



Source Code in .c and .h files

Compiler

Object code in .o or .obj file.

Linker

Executable program.

Run

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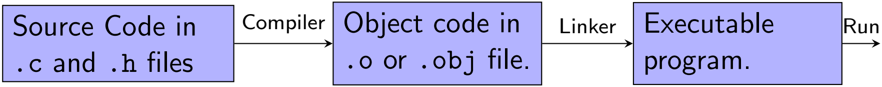
    return(z);
}
```

The **function declaration**, goes at the top or in its own header file. As the function declaration only needs to know the **type** of the input parameters, the name of the variable can be omitted.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    return 0;
}
int printAndAdd (int x, int y) { // function definition
    int z=x+y;
    printf("In function printAndAdd: x+y=%d\n",z);
    return(z);
}
```
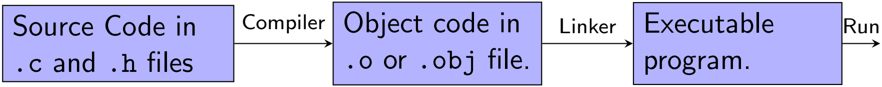

The **function call** can be made after function has been declared.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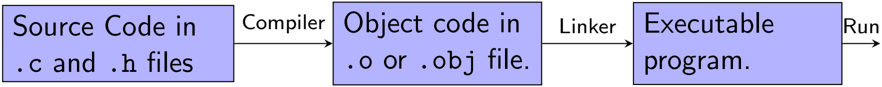
    return 0;
}
int printAndAdd (int x, int y) { // function definition
    int z=x+y;
    printf("In function printAndAdd: x+y=%d\n",z);
    return(z);
}
```

The **function definition** is not needed until the linking stage. It can go in its own file and be compiled separately.



Source Code in .c and .h files

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Object code in .o or .obj file.

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Functions in POP and OOP

Functions are the heart of POP (procedural-oriented programming).

- Every chunk of code that performs a self-contained task with potential for re-use should be separated out into its own function.
- In bigger projects, functions are separated into their own file and compiled separately
  - Enables more modular code with easier re-use
  - The function file can be compiled separately and independently from the main.
  - No need to recompile subfunctions, when working on the main.

Functions are still used in OOP (object-oriented programming), but they are bundled together with data of the object.

- This helps to manage the functions better.
- Function management is important as project grows in size

Function example: prime number

Code without functions/comments

```
for (i=1,k=3;i<N;k++) {
   for (j=0;j<i;j++) {
      if (k%x[j]==0)
         goto notPrime;
   }
   printf("%3d %6d\n",i,k);
   x[i]=k;
   i++;
   notPrime:
}
```

Code with functions/comments

```
// Iterate over each test
// number k
for (i=1,k=3;i<N;k++) {
   if (isPrime(k,x,i)) {
      printf("%3d %6d\n",i,k);
// Save prime, and increment
      x[i]=k;
      i++;
   }
}
```

You should aim to produce the code on the right.

Functions: Call by reference vs call by value

1. Call-by-value

```
int printAndAdd (int x, int y); // function declaration

int main () {
    int x=printAndAdd(3,6); // function call
}
```

In call-by-value, when the function is called, the **value** in the calling environment is **copied** into the variables in the local function.
⇒ function **unable** to affect variables in calling environment.

2. Call-by-reference

```
int printAndAdd (int* x, int* y); // function declaration

int main () {
    int x=3,y=6,z=printAndAdd(&x,&y); // function call
}
```

In call-by-reference, the **address** of the variable in the calling environment is passed to the variables in the local function.
⇒ function **is able** to affect variables in calling environment.

Functions: Call by reference vs call by value

1. Call-by-value

```
int printAndAdd (int x, int y); // function declaration

int main () {
    int x=printAndAdd(3,6); // function call
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values copied into local variables

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2. Call-by-reference

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int printAndAdd (int* x, int* y); // function declaration

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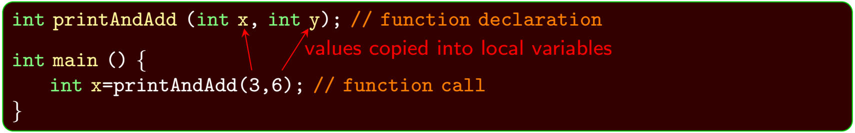
Functions: Call by reference vs call by value

1. Call-by-value



```
int printAndAdd (int x, int y); // function declaration

int main () {
    int x=printAndAdd(3,6); // function call
}
```

values copied into local variables

In call-by-value, when the function is called, the **value** in the calling environment is **copied** into the variables in the local function.
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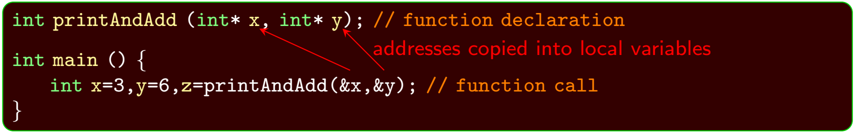
2. Call-by-reference



```
int printAndAdd (int* x, int* y); // function declaration

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}
```

addresses copied into local variables

In call-by-reference, the **address** of the variable in the calling environment is passed to the variables in the local function.
⇒ function **is able** to affect variables in calling environment.

Example: Call-by-value

```c
#include <stdio.h>
int printAndAdd (int x, int y) { // function definition
    int z=x+y;
    printf("In function printAndAdd: x+y=%d\n",z);
// Reassign input variables, to see if affects calling environment
    x=100; y=100;
    printf("In printAndAdd, reassigning x and y: x=%d, y=%d\n",x,y);
    return(z);
}
int main () {
    int x=3, y=6, z;
    z=printAndAdd(x,y); // function call
    printf("Inside main function: x=%d, y=%d, z=%d\n",x,y,z);
    return 0;
}
```

Example: Call-by-value

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    z=printAndAdd(x,y); // function call
    printf("Inside main function: x=%d, y=%d, z=%d\n",x,y,z);
    return 0;
}
```

Output:

```
In function printAndAdd: x+y=9
In printAndAdd, reassigning x and y: x=100, y=100
Inside main function: x=3, y=6, z=9
```

Example: Call-by-value

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#include <stdio.h>
int printAndAdd (int x, int y) { // function definition
    int z=x+y;
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int main () {
    int x=3, y=6, z;
    z=printAndAdd(x,y); // function call
    printf("Inside main function: x=%d, y=%d, z=%d\n",x,y,z);
    return 0;
}
```

Output:

```
In function printAndAdd: x+y=9
In printAndAdd, reassigning x and y: x=100, y=100
Inside main function: x=3, y=6, z=9
```

⇒ Variables in function scope **do not** affect variables in calling scope

Call-by-value

Calling by value has limitations.

1. You can't pass an array when using call-by-value.
    - Arrays are pointers, and passing a pointer ot the array is using call-by-reference
    - Call-by-value only passes single values.
2. C functions can only return a single value
    - If you want your function to return more than one value, you must use call-by-reference:
    - Pass the address of an output variable to the function.
    - Function modifies the variable in the calling environment.

Example: Call-by-reference

```c
#include <stdio.h>
int printAndAdd (int* x, int* y) { // function definition
    int z=*x+*y;
    printf("In function printAndAdd: *x+*y=%d\n",z);
// Reassign input variables, to see if affects calling environment
    *x=100; *y=100;
    printf("In printAndAdd, reassigning *x and *y: x=%d, y=%d\n",*x,*y);
    return(z);
}
int main () {
    int x=3, y=6, z;
    z=printAndAdd(&x,&y); // function call
    printf("Inside main function: x=%d, y=%d, z=%d\n",x,y,z);
    return 0;
}
```

Example: Call-by-reference

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int printAndAdd (int* x, int* y) { // function definition
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// Reassign input variables, to see if affects calling environment
    *x=100; *y=100;
    printf("In printAndAdd, reassigning *x and *y: x=%d, y=%d\n",*x,*y);
    return(z);
}
int main () {
    int x=3, y=6, z;
    z=printAndAdd(&x,&y); // function call
    printf("Inside main function: x=%d, y=%d, z=%d\n",x,y,z);
    return 0;
}
```

Output:

```
In function printAndAdd: *x+*y=9
In printAndAdd, reassigning *x and *y: x=100, y=100
Inside main function: x=100, y=100, z=9
```

Example: Call-by-reference

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    int z=*x+*y;
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int main () {
    int x=3, y=6, z;
    z=printAndAdd(&x,&y); // function call
    printf("Inside main function: x=%d, y=%d, z=%d\n",x,y,z);
    return 0;
}
```

Output:

```
In function printAndAdd: *x+*y=9
In printAndAdd, reassigning *x and *y: x=100, y=100
Inside main function: x=100, y=100, z=9
```

⇒ Variables in function scope **can** affect variables in calling scope

Call-by-reference example: Incrementing an array

```c
#include <stdio.h>
void printArray(int *a, int N) {
    // print all elements in array a[] of length N
    int i;
    for (i=0;i<N;i++) printf("%3d %3d\n",i,a[i]);
}
void incrementArray(int *a, int N) {
    int i;
    // update all elements in array a[] of length N.
    for (i=0;i<N;i++) a[i]++;
}
int main () {
    int a[]={20, 15, 18, 33, 25, 13};
    printf("Before increment\n");
    printArray(a,6);
    incrementArray(a,6);
    printf("After increment\n");
    printArray(a,6);
    return 0;
}
```

Call-by-reference example: Incrementing an array

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void incrementArray(int *a, int N) {
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    for (i=0;i<N;i++) a[i]++;
}
int main () {
    int a[]={20, 15, 18, 33, 25, 13};
    printf("Before increment\n");
    printArray(a,6);
    incrementArray(a,6);
    printf("After increment\n");
    printArray(a,6);
    return 0;
}
```

Output:

```
Before increment
0 20
1 15
2 18
3 33
4 25
5 13
After increment
0 21
1 16
2 19
3 34
4 26
5 14
```

Recursive functions

- Recursive functions are a special type of function that are allowed to call themselves.
- You might think this could result in an infinite loop, which it can if you do not control the exit condition properly
- Recursion is a useful tool to in certain cases such as in the case of computing factorials:
  Definition: $n! = n \times (n-1)!$ for $n \geq 1$ and
  $0! = 1$
- We can use recursion to evaluate $n!$ by multiplying n by $(n-1)!$, ie: a function calling itself.
- The terminating condition is that when $n = 0$ the function should return 1.

Example Recursion: Computing Factorial

```c
#include <stdio.h>
// Recursive function factorial
long unsigned int factorial (long unsigned int n) {
    if (n==0) return(1); // 0! = 1
    else return(n*factorial(n-1));
}
int main () {
    int i;
    for (i=0;i<10;i++) printf("%d! = %lu\n",i,factorial(i));
    return 0;
}
```

Example Recursion: Computing Factorial

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}
int main () {
    int i;
    for (i=0;i<10;i++) printf("%d! = %lu\n",i,factorial(i));
    return 0;
}
```

Output:

```
    0! = 1
    1! = 1
    2! = 2
    3! = 6
    4! = 24
    5! = 120
    6! = 720
    7! = 5040
    8! = 40320
    9! = 362880
```

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Generating Random Numbers

- Sometimes you need the computer to generate random numbers for your program
- Computers cannot generate truly random numbers, but they can generate **pseudo-random** numbers.
- **Pseudo-random numbers generators** (PRNG) are an algorithm that produce numbers having the appearance of being random.
  - However pseduo-random numbers are not truly random. They will repeat with some period N.
  - If the period of repetition is large enough, then for all intents and purposes, the numbers will be random.
- The issue with PRNGs is about making the period big enough that the output never repeats within the duration of usage.

The Standard C PRNG

Reference: Press, Teukolsky, Vetterling Flannery "Numerical Recipes in C", Second Edition, chapter 7.

The synopsis for generating random numbers using the standard C library routine is:

```
#include <stdlib.h>
#define RAND_MAX ...
void srand(unsigned seed);
int rand(void);
```

- The function `void srand(unsigned seed);` initializes the random seed to the given value. This value is used to seed the random number generator that allows it to generate the future random number sequences.
- The function `int rand (void);` returns an integer between 0 and `RAND_MAX` **inclusive**.

Example generating random numbers

```c
#include<stdio.h>
#include<stdlib.h>
int main () {
   srand(1); // Initialize the random seed
   printf("Random number: %d\n",rand());
   printf("Random number: %d\n",rand());
   printf("Random number: %d\n",rand());
   printf("Random number: %d\n",rand());
   printf("RAND_MAX=%d\n",RAND_MAX);
   return 0;
}
```

Output:

```
Random number: 1804289383
Random number: 846930886
Random number: 1681692777
Random number: 1714636915
RAND_MAX=2147483647
```

The same seed should generate the same random sequence of numbers.

Generating uniformly distributed floats

To generate a uniformly distributed random floating number, between 0 and 1 divide by (RAND_MAX+1.0):

```
#include<stdio.h>
#include<stdlib.h>
int main () {
   printf("Random number:%f\n",rand()/(RAND_MAX+1.0));
   printf("Random number:%f\n",rand()/(RAND_MAX+1.0));
   printf("Random number:%f\n",rand()/(RAND_MAX+1.0));
   printf("Random number:%f\n",rand()/(RAND_MAX+1.0));
   return 0;
}
```

Output:

```
Random number: 0.840188
Random number: 0.394383
Random number: 0.783099
Random number: 0.798440
```

The same seed should generate the same random sequence of numbers.

Generating uniform integers between 1 and 10

To generate uniformly distributed random integers between 1 and 10 use the most significant bits (MSBs):

`1+(int) (10.0*rand()/(RAND_MAX+1.0));`

```
#include<stdio.h>
#include<stdlib.h>
int main () {
   int x;
   x=1+(10.0*rand())/(RAND_MAX+1.0);
   printf("Random number: %d\n",x);
   x=1+(10.0*rand())/(RAND_MAX+1.0);
   printf("Random number: %d\n",x);
   return 0;
}
```

Output:

```
Random number: 9
Random number: 4
```

Don't use the LSB's, ie: don't do: `(rand()%10)+1.0`.

Generating uniform integers between 1 and 10

To generate uniformly distributed random integers between 1 and 10 use the most significant bits (MSBs):

`1+(int) (10.0*rand()/(RAND_MAX+1.0));`

The MSB's and LSB's of the a 4-byte integer:

1	1	0	0	0	1	0	1	1	0	1	0	1	1	1	0	0	1	0	0	1	1	0	1	1	1	0	1	0	1	0	0

MSB's

LSB's

```
    x=1+(10.0*rand())/(RAND_MAX+1.0);
    printf("Random number: %d\n",x);
    x=1+(10.0*rand())/(RAND_MAX+1.0);
    printf("Random number: %d\n",x);
    return 0;
}
```

Output:

```
Random number: 9
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```

Don't use the LSB's, ie: don't do: `(rand()%10)+1.0`.

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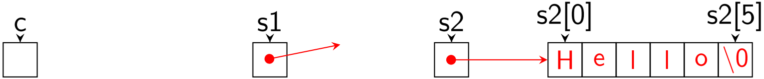
Refresher on Strings Chars and Pointers

- In C, strings are just arrays of chars.

```
char c;             // c is a single char
char *s1;          //s1 is a pointer to a char
char s2[]="Hello"; //s2 is an array of 6 chars.
```

- A pointer is a **memory address pointing** to a location in memory. s1 is a pointer (because of the *), it holds an **address in memory**. *s1 refers to the contents of the memory address pointed to by s1.



c is a char that the compiler uses to refer to 1 byte of memory, interpreted as a char.

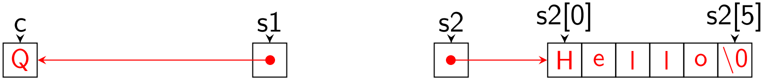
s1 is a pointer to a char. It consumes 4 or 8 bytes of memory. When declared, but uninitialized it is pointing randomly.

s2 is a pointer (because of the []) that is declared and initialized. 6 bytes of memory are allocated and filled with the string "Hello\0". `printf("%s",s2);` is valid. `printf("%s",s1);` has undefined behaviour

Strings Chars and Pointers

- In C, strings are just arrays of chars.

```
char c;              // c is a single char
char *s1;           //s1 is a pointer to a char
char s2[]="Hello"; //s2 is an array of 6 chars.
c='Q'; //Assign a value to the memory of c
s1=&c; // store the address of c into s1
```



On assignment, the compiler puts the value into the memory associated with c

On assignment, the **address** of c (denoted by &c) is stored in s1. Now *s1 is an alias s1[0] is an alias for c

s2 is a pointer (because of the []) that is declared and initialized. 6 bytes of memory are allocated and filled with the string "Hello\0". printf("%s",s2); is valid.

printf("%s",s1) is now valid, but the string pointed to by s1 is unterminated: There is no '\0' character terminating the char c which only has 8 bits allocated.

Strings Chars and Pointers: Example

```
#include <stdio.h>
int main () {
   char c;   // c is a single char
   char *s1;  //s1 is a pointer to a char
   char s2[]="Hello";  //s2 is a pointer to an array of 6 chars.
   c=’Q’; //Assign a value to the memory of c
   s1=&c; // Assign the address of c to memory of s1
   printf("Before: c=%c\n",c);  //Print c as char
   printf("Before: *s1=%c\n",*s1);//Print s1 as char
   printf("Before: s1=%s\n",s1);  //Print s1 as string
   *s1=’W’;// reassign the value of *s1 (alias for c)
   printf("After: c=%c\n",c); //Print c as char
   printf("After: *s1=%c\n",*s1);//Print s1 as char
   return(0);
}
```

Strings Chars and Pointers: Example

```
#include <stdio.h>
int main () {
   char c;   // c is a single char
   char *s1;  //s1 is a pointer to a char
   char s2[]="Hello"; //s2 is a pointer to an array of 6 chars.
   c=’Q’; //Assign a value to the memory of c
   s1=&c; // Assign the address of c to memory of s1
   printf("Before: c=%c\n",c);  //Print c as char
   printf("Before: *s1=%c\n",*s1);//Print s1 as char
   printf("Before: s1=%s\n",s1); //Print s1 as string
   *s1=’W’;// reassign the value of *s1 (alias for c)
   printf("After: c=%c\n",c); //Print c as char
   printf("After: *s1=%c\n",*s1);//Print s1 as char
   return(0);
}
```

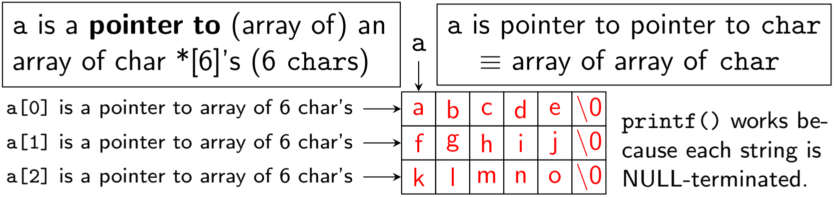
```
Before: c=Q
Before: *s1=Q
Before: s1=Q(rubbish text)
After: c=W
After: *s1=W
```

2D string arrays

```c
#include <stdio.h>
int main () {
   // Declare and initialize 2D char array
   char a[3][6]={"abcde","fghij","klmno"};
   printf("a[0]=%s\n",a[0]);
   printf("a[1]=%s\n",a[1]);
   printf("a[2]=%s\n",a[2]);
   return 0;
}
```

Output:

```
a[0]=abcde
a[1]=fghij
a[2]=klmno
```



a is a **pointer to** (array of) an array of char *[6]'s (6 chars)

a is pointer to pointer to char ≡ array of array of char

a

a[0] is a pointer to array of 6 char's →

a[1] is a pointer to array of 6 char's →

a[2] is a pointer to array of 6 char's →

a	b	c	d	e	\0
f	g	h	i	j	\0
k	l	m	n	o	\0

printf() works because each string is NULL-terminated.

a[0][0] is the first element in the array a[0]='a'

a[1][0] is the first element in the array a[1]='f'

a[2][0] is the first element in the array a[2]='k'

Initializing 2D int arrays

```
#include <stdio.h>
int main () {
    //How to initialize a 2D int array:
    int a[3][4]={
            {0, 1, 2, 3} , /* initializers for a[0] */
            {4, 5, 6, 7} , /* initializers for a[1] */
            {8, 9, 10, 11} /* initializers for a[2] */
    };
    printf("a[0][0]=%d\n",a[0][0]);
    printf("a[1][1]=%d\n",a[1][1]);
    printf("a[2][2]=%d\n",a[2][2]);
    printf("a[2][3]=%d\n",a[2][3]);
    printf("a[3][3]=%d\n",a[3][3]);
    return 0;
}
```

Initializing 2D int arrays

```
#include <stdio.h>
int main () {
    //How to initialize a 2D int array:
    int a[3][4]={
           {0, 1, 2, 3} , /* initializers for a[0] */
           {4, 5, 6, 7} , /* initializers for a[1] */
           {8, 9, 10, 11} /* initializers for a[2] */
    };
    printf("a[0][0]=%d\n",a[0][0]);
    printf("a[1][1]=%d\n",a[1][1]);
    printf("a[2][2]=%d\n",a[2][2]);
    printf("a[2][3]=%d\n",a[2][3]);
    printf("a[3][3]=%d\n",a[3][3]);
    return 0;
}
```

Output:

```
    a[0][0]=0
    a[1][1]=5
    a[2][2]=10
    a[2][3]=11
```

Example: Printing/processing 2D int array

```c
#include <stdio.h>
int main () {
    //How to print a 2D int array:
    int a[3][4]={
              {0, 1, 2, 3} , /* initializers for a[0] */
              {4, 5, 6, 7} , /* initializers for a[1] */
              {8, 9, 10, 11} /* initializers for a[2] */
    };
    int i,j;
    for (i=0;i<3;i++) {
        for (j=0;j<4;j++) {
            printf(" %2d",a[i][j]);
        }
        printf("\n");
    }
    return 0;
}
```

Example: Printing/processing 2D int array

```
#include <stdio.h>
int main () {
    //How to print a 2D int array:
    int a[3][4]={
            {0, 1, 2, 3} , /* initializers for a[0] */
            {4, 5, 6, 7} , /* initializers for a[1] */
            {8, 9, 10, 11} /* initializers for a[2] */
    };
    int i,j;
    for (i=0;i<3;i++) {
        for (j=0;j<4;j++) {
            printf(" %2d",a[i][j]);
        }
        printf("\n");
    }
    return 0;
}
```

Output:

```
  0 1 2 3
  4 5 6 7
  8 9 10 11
```

Example: Printing/processing 2D char array

```
#include <stdio.h>
int main () {
    //How to print a 2D int array:
    int i,j;
    for (i=0;i<5;i++) {
        for (j=0;j<5;j++) {
            printf(" %c",’a’+i*5+j);
        }
        printf("\n");
    }
    return 0;
}
```

Example: Printing/processing 2D char array

```
#include <stdio.h>
int main () {
    //How to print a 2D int array:
    int i,j;
    for (i=0;i<5;i++) {
        for (j=0;j<5;j++) {
            printf(" %c",’a’+i*5+j);
        }
        printf("\n");
    }
    return 0;
}
```

Output:

```
 a b c d e
 f g h i j
 k l m n o
 p q r s t
 u v w x y
```

Example: Printing/processing 2D char array

```
#include <stdio.h>
int main () {
    //How to print a 2D int array:
    int i,j;
    for (i=0;i<5;i++) {
        for (j=0;j<5;j++) {
            printf(" %c",’a’+i*5+j);
        }
        printf("\n");
    }
    return 0;
}
```

Output:

```
    a b c d e
    f g h i j
    k l m n o
    p q r s t
    u v w x y
```

Note: that while the previous example used a 2D array of ints, this current example does not use a 2D array of chars, it is calculating each char directly from the indices `i` and `j`.

C string library

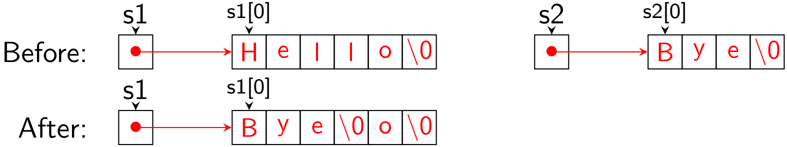
In C, as per the POP programming paradigm, there is a library of functions for handling strings. To access the C-string library in C, you need to `#include<string.h>`

The common C-string functions are listed here:

`strcpy(s1, s2);`	Copies string s2 into string s1.
`strcat(s1, s2);`	Concatenate string s2 onto the end of s1.
`strlen(s1);`	Returns the length of s1.
`strcmp(s1, s2);`	Returns 0 if s1 is same as s2. Returns +1 or -1 if s2 is greater or less than s1
`strchr(s1, ch);`	Returns pointer to first occurence of character ch in string s1.
`strstr(s1, s2);`	Returns pointer to first occurence of string s2 in string s1.

Example: strcpy(char *s1, char *s2);

Copy string s2 into string s1. s1 must hold sufficient memory.



Before: s1 → s1[0]: | H | e | l | l | o | \0 | s2 → s2[0]: | B | y | e | \0 |

After: s1 → s1[0]: | B | y | e | \0 | o | \0 |

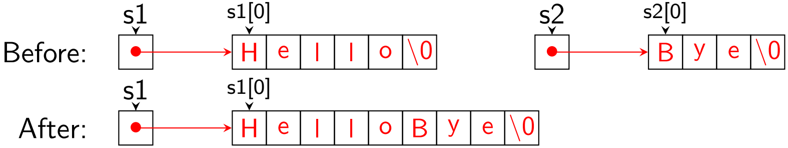
```
#include<stdio.h>
#include<string.h>
int main () {
    char s1[]="Hello";
    char s2[]="Bye";
    strcpy(s1,s2);
    printf("s1=%s\n",s1);
    return 0;
}
```

Output:

```
s1=Bye
```

Example: strcat(char *s1, char *s2);

Concatenate s2 onto end of s1. s1 must hold enough memory.



Before: s1 → s1[0]: H e l l o \0 s2 → s2[0]: B y e \0

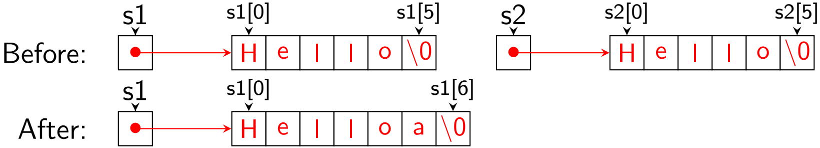
After: s1 → s1[0]: H e l l o B y e \0

```
#include<stdio.h>
#include<string.h>
int main () {
    char s1[10]="Hello";
    char s2[]="Bye";
    strcat(s1,s2);
    printf("s1=%s\n",s1);
    return 0;
}
```

Output:

```
s1=HelloBye
```

Example: strcmp(char *s1, char *s2);



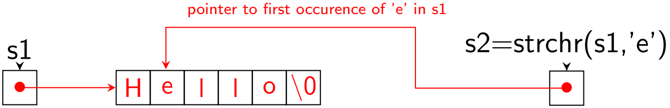
```
#include<stdio.h>
#include<string.h>
int main () {
   char s1[10]="Hello";
   char s2[]="Hello";
   printf("Before strcat=%d\n",strcmp(s1,s2));
   strcat(s1,"a");
   printf("After strcat=%d\n",strcmp(s1,s2));
   return 0;
}
```

Output:

```
Before strcat=0
After strcat=97
```

Example: strchr(char *s1, char c);

Search for first occurence of character ’e’ in s1



pointer to first occurence of ’e’ in s1

s1

H | e | l | l | o | \0

s2=strchr(s1,’e’)

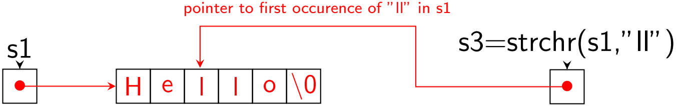
```
#include<stdio.h>
#include<string.h>
int main () {
   char s1[10]="Hello";
   char *s2=strchr(s1,’e’);
   printf("s2=%s\n",s2);
   return 0;
}
```

Output:

```
s2=ello
```

Example: strstr(char *s1, char* s2);

Search for first occurence of string ”ll” in s1



pointer to first occurence of ”ll” in s1

s1

H e l l o \0

s3=strchr(s1,”ll”)

```
#include<stdio.h>
#include<string.h>
int main () {
   char s1[10]="Hello";
   char *s3=strstr(s1,"ll");
   printf("s3=%s\n",s3);
   return 0;
}
```

Output:

```
s3=llo
```

External resources

Sites to learn about C functions:

- www.tutorialspoint.com
- www.programiz.com
- tutorialsclass.com
- www.w3schools.in

Numerical recipes in C, Chapt 7 for random numbers:

- Numerical Recipes in C

Some external sites you can go to learn about C strings:

- www.tutorialspoint.com
- www.programiz.com
- www.programiz.net
- www.cprogramming.com
- www.tutorialkart.com