NATIONAL UNIVERSITY OF COMPUTER AND EMERGING SCIENCES

CL 103 - COMPUTER PROGRAMMING LAB

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Lab # 02

Outline

- Pointers
- Pointers to array
- Double Pointers
- Dynamic Memory Management (new and delete operators)
- Pointer to function OR Function Pointer
- Pointer and multidimensional array
- Dynamic Memory Management
- What is a function?
- Void function
- The Function returns a value
- What is recursion?
- Direct Vs Indirect Recursion
- Exercise

POINTERS

Pointer is a variable whose value is a memory address. Normally, a variable directly contains a specific value. A pointer contains the memory address of a variable that, in turn, contains a specific value. In this sense, a variable name directly references a value, and a pointer indirectly references a value.

REFERENCE OPERATOR (&)

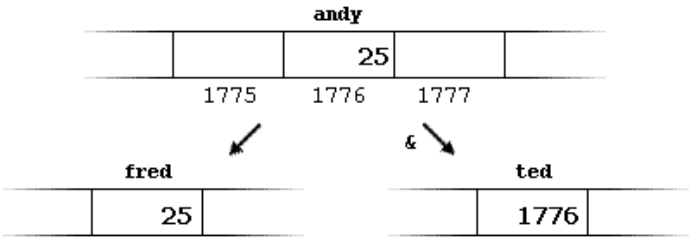
The address that locates a variable within memory is what we call a reference to that variable.

```
ted = &andy;
```

assume that andy is placed during runtime in the memory address 1776.

```
andy = 25;
fred = andy;
ted = &andy;
```

The values contained in each variable after the execution of this, are shown in the following diagram:

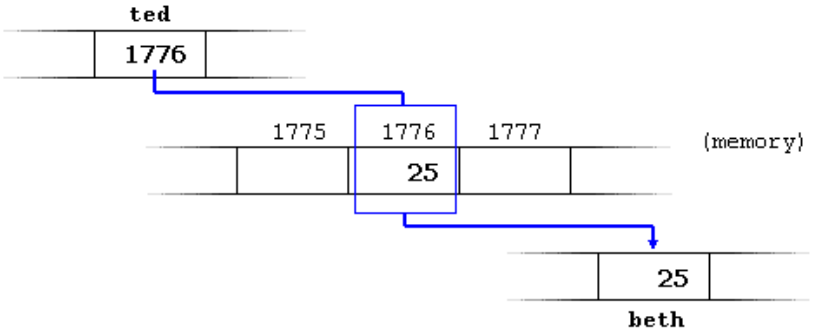


DE-REFERENCE OPERATOR (*)

The asterisk (*) acts as a dereference operator and that can be translated to "value pointed by".

beth = *ted;

We could read as: "beth equal to value pointed by ted", beth would take the value 25, since ted is 1776, andthe value pointed by 1776 is 25.



POINTER TYPE DECLARATION

SYNTAX: type * variable ;

EXAMPLE: int *ptr, char * character, float * greatvalue;

EXPLANATION: The value of the pointer variable ***ptr*** is a memory address. A data item whose address is stored in this variable must be of the specified type.

```
// more pointers
#include <iostream>
using namespace std;

int main ()
{
  int firstvalue = 5, secondvalue = 15;
  int * p1, * p2;

  p1 = &firstvalue;  // p1 = address of firstvalue
  p2 = &secondvalue; // p2 = address of secondvalue
  *p1 = 10;          // value pointed by p1 = 10
  *p2 = *p1;         // value pointed by p2 = value pointed by
p1
  p1 = p2;           // p1 = p2 (value of pointer is copied)
  *p1 = 20;          // value pointed by p1 = 20

  cout << "firstvalue is " << firstvalue << endl;
  cout << "secondvalue is " << secondvalue << endl;
  return 0;
}
```

```
firstvalue is 10
secondvalue is 20
```

POINTERS AND ARRAYS

The identifier of an array is equivalent to the address of its first element, as a pointer is equivalent to the address of the first element that it points to.

EXAMPLE: *Assume the following declaration:*
int numbers [20];
int * p;
The following assignment operation would be valid:
p = numbers;

```
// more pointers
#include <iostream>
using namespace std;

int main ()
{
  int numbers[5];
  int * p;
  p = numbers;  *p = 10;
  p++;  *p = 20;
  p = &numbers[2];  *p = 30;
  p = numbers + 3;  *p = 40;
  p = numbers;  *(p+4) = 50;
  for (int n=0; n<5; n++)
    cout << numbers[n] << ", ";
  return 0;
}
```

```
10, 20, 30, 40, 50,
```

POINTER INITIALIZATION

When declaring pointers we can explicitly specify which variable we want them to point to.

EXAMPLE: int number;

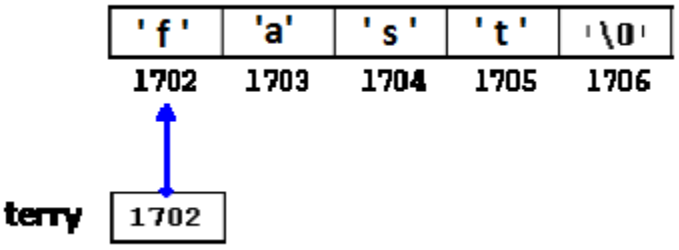
```
int *tommy = &number;
```

The above code is equivalent to:

```
int number;
int *tommy;
tommy = &number;
```

We can also initialize the content at which the pointer points with constants at the same moment the pointer is declared:

EXAMPLE: `char * terry = "fast";`
Assuming that "fast" is stored at the memory locations that start at addresses1702, we can represent the previous declaration as:



POINTER ARITHMETIC

Only addition and subtraction operations are allowed with pointers. Furthermore, when incrementing a pointer, the size in bytes of the type pointed to is added to the pointer.

EXAMPLE:

```
char *mychar;       //points to memory location 1000
short *myshort;     //points to memory location 2000
long *mylong;       //points to memory location 3000

mychar++;           //mychar now contains 1001
myshort++;          //myshort now contains 2002
mylong++;           //mylong now contains 3004
```

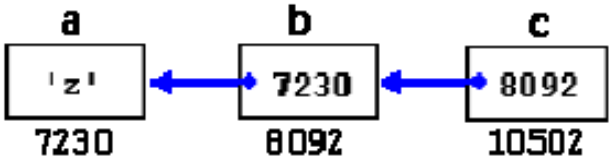
POINTERS TO POINTERS (DOUBLE POINTER)

C++ allows the use of pointers that point to pointers, that these, in its turn, point to data (or even to other pointers). In order to do that, we only need to add an asterisk (*) for each level of reference in their declarations:

EXAMPLE:

```
char a;
char * b;
char ** c;

a = 'z';
b = &a;
c = &b;
```

This, supposing the randomly chosen memory locations for each variable of 7230, 8092 and 10502, could berepresented as:



- c has type char** and a value of 8092
- *c has type char* and a value of 7230
- **c has type char and a value of 'z'

VOID POINTER

Void pointersare pointers that can point to any data type. One limitation of void pointers is that they cannot be directly de-referenced.

EXAMPLE:

```
// increaser
#include <iostream>
using namespace std;

void increase (void* data, int psize)
{
  if ( psize == sizeof(char) )
  { char* pchar; pchar=(char*)data; ++(*pchar); }
  else if (psize == sizeof(int) )
  { int* pint; pint=(int*)data; ++(*pint); }
}

int main ()
{
  char a = 'x';
  int b = 1602;
  increase (&a,sizeof(a));
  increase (&b,sizeof(b));
  cout << a << ", " << b << endl;
  return 0;
}
```

```
y, 1603
```

NULL POINTER

A null pointer is a regular pointer of any pointer type which has a special value that indicates that it is not pointingto any valid reference or memory address.

EXAMPLE:

```
int * p;
p = 0;          // p has a null pointer value
```

Do not confuse null pointers with void pointers. A null pointer is a value that any pointer may take to represent that it is pointing to "nowhere", while a void pointer is a special type of pointer that can point to some where without a specific type.

POINTERS TO FUNCTIONS

C++ allows operations with pointers to functions. The typical use of this is for passing a function as an argument to another function, since these cannot be passed de-referenced.

EXAMPLE:

```
// pointer to functions
#include <iostream>
using namespace std;

int addition (int a, int b)
{ return (a+b); }

int subtraction (int a, int b)
{ return (a-b); }

int operation (int x, int y, int
(*functocall)(int,int))
{
  int g;
  g = (*functocall)(x,y);
  return (g);
}

int main ()
{
  int m,n;
  int (*minus)(int,int) = subtraction;

  m = operation (7, 5, addition);
  n = operation (20, m, minus);
  cout <<n;
  return 0;
}
```

DYNAMIC MEMORY ALLOCATION

MEMORY ALLOCATION

There are two ways through which memory can be allocated to a variable. They are ***static allocation*** of memory and ***dynamic memory allocation***. So far, we have declared variable and array statically. This means at compile time memory is allocated to variable or array.

Example of static memory allocation

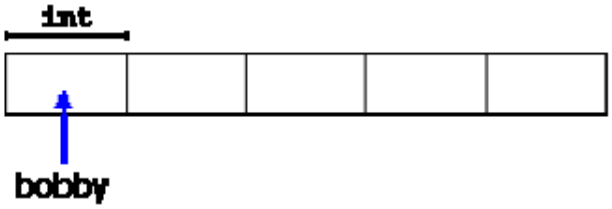
int a = 10;

Dynamic Memory Allocation examples

Dynamic memory allocation is needed if we want a variable amount of memory that can only be determined during runtime.
When we talk about dynamic memory allocation or runtime memory allocation, two keywords are important in ***C++.*** They are ***new*** and ***delete***.

- ***new and new[ ] operator***

new operator is used to dynamically allocate memory. When we allocate memory using new keyword a pointer is needed. This is so because new allocates memory and dynamically and it returns address to allocated memory and this returned memory address is stored in a pointer variable.



dynamically memory allocation for a variable

General Synatx for dynamically memory allocation for a variable
Pointer = new type;

Example
*int *ptr;* *ptr = new int;*// dynamically memory allocated for an integer and address of allocated memory is stored in ptr

Accessing value stored at the address in pointer variable (single variable)

Value at address stored in pointer variable will be accessed by dereference '*' operator as it is normally done.

Example
*int *ptr;* *ptr = new int;* **ptr = 10; // dereferencing pointer*

dynamically memory allocation for an array

General Synatx for dynamically memory allocation for an array
Pointer = new type[size];

Example
*int *ptr;* *ptr = new int[10];*// dynamically memory allocated for an integer array of size 10 and address of first element of array is stored in ptr

Accessing value stored at the address in pointer variable (array)

This can be done in two ways.

1. Use ***pointer subscript notation***. i.e ptr[0] = 10, ptr[1] = 20 etc.
   OR
2. Use ***deferencing operator.*** i.e *(ptr+0) = 10, *(ptr+1) = 20;

- ***delete and delete[ ] operator***

To free dynamic memory after it is used, **delete** operator is used so that the memory becomes available again for other requests of dynamic memory.

```
#include<iostream>
using namespace std;
int main()
{
	system("color 70");
	int i,n;
	int *p;
	cout<<"How many numbers would you like
to type? ";
	cin>>i;
	p = new int[i];
	for(n=0;n<i;n++)
	{
		cout<<"Enter Number: ";
		cin>>p[n];
	}
	cout<<endl<<"You have entered: ";
	for(n=0;n<i;n++)
	{
		cout<<p[n]<<",";

	}
	cout<<endl<<endl;

	delete[] p;

	cout<<"After deallocation, You have
entered: ";
	for(n=0;n<i;n++)
	{
		cout<<p[n]<<",";
	}
}
```

```
How many numbers would you like to type? 5
Enter Number: 1
Enter Number: 2
Enter Number: 3
Enter Number: 4
Enter Number: 5

You have entered: 1,2,3,4,5,

After deallocation, You have entered: 9198608,0,9175384,0,5,
--------------------------------
Process exited after 6.403 seconds with return value 0
Press any key to continue . . .
```

POINTER TO FUNCTION OR FUNCTION POINTER

The function pointer is actually a variable which points to the address of a function.

Function Pointers provide an extremely interesting, efficient and elegant programming technique. You can use them to replace switch/if-statements, and to realize late-binding.

Late binding refers to deciding the proper function during runtime instead of compile time.

Unfortunately function pointers have complicated syntax and therefore are not widely used. If at all, they are addressed quite briefly and superficially in textbooks. They are less error prone than normal pointers because you will never allocate or deallocate memory with them.

Define a function pointer

Since a function pointer is nothing else than a variable, it must be defined as usual.

General Syntax

*Return_type (*name_of_pointer_variable) (data type of arguments separated by comma) = NULL;*

In the following example, we define a function pointer named function_ptr. It points to a function, which takes two integersand returns a float value.

Example – Declare function pointer

float (function_pointer) (int, int) = NULL;

Assign an address to function pointer

It's quite easy to assign the address of a function to a function pointer. You simply take the name of a suitable and known function or member function. Although it's optional for most compilers you should use the address operator & infront of the function's name in order to write portable code.

Example

```
float division(int a, int b)
{
        return a/b;
}

function_ptr = division; //short form
function_ptr = &division; //assignment using address operator

}
int main()
{
        float (*func_ptr)(float,float)=NULL;

        func_ptr = &division;
        float result = (*func_ptr)(9, 5);

        cout<<result <<endl;

        func_ptr = division;
        result = (*func_ptr)(9, 5);

        cout<<result <<endl;

        return 0;
}
```

Pass function pointer as an argument

You can pass a function pointer as a function's calling argument. You need this for example if you want to pass

a pointer to a callback function. The following code shows how to pass a pointer to a function which returns an int and takes a float and two char.

Example

```
#include<iostream>
using namespace std;

int DoIt (float a, char b, char c)
{
        printf("DoIt\n");
        return a+b+c;
}
void PassPtr(int (*pt2Func)(float, char, char))
{
        int result = (*pt2Func)(12, 'a', 'b');
        // call using function pointer printf("%d", result);
}
void Pass_A_Function_Pointer()
{
        printf("Executing 'Pass_A_Function_Pointer'\n");
        PassPtr(&DoIt);
}
int main()
{
        Pass_A_Function_Pointer();
}
```

FUNCTION

A function is a group of statements that together perform a particular task. Every C++ program has atleast one function and that is a main function.

Based on the nature of task, we can divide up our program into several functions.

What are local variables?

These are the variables that are declared in the function. Their lifetime ends when the execution of the function finishes and are only known in the function in which they are declared.

Function returns a value

Value returning functions are used when only one result is returned and that result is used directly in an expression.

General Format of a function return a value

```
datatype nameOfFunction()
{
        return variable;
}
```

Void Function

Void functions are used when function doesn't return a value.

General Format of a void function

```
void nameOfFunction()
{
        Statement1;
        Statement2;
        …
        Statement n;
}
```

RECURSION

When a function repeatedly calls itself, it is called a recursive function and the process is called recursion.

It seems like a never ending loop, or more formally it seems like our function will never finish. In some cases, this might true, but in practice we can check if a certain condition becomes true then return from the function.

Base Case

The case/condition in which we end our recursion is called a base case.

Example of finite recursion

```
#include<iostream>
using namespace std;
void myFunction( int counter)
{
        if(counter == 0)
                return;
        else
   {
                cout <<counter<<endl;
                myFunction(--counter);
                return;
   }
```

```
}

int main()
{
        myFunction(10);
}
```

Characteristics of Recursion

Every recursion should have the following characteristics.

1. A simple ***base case*** which we have a solution for and a return value. Sometimes there are more than one base cases.
2. A way of getting our problem closer to the base case. i.e. a way to chop out part of the problem to get a somewhat simpler problem.
3. A recursive call which passes the simpler problem back into the function.

General Format

```
returntype recursive_func ([argument list])
{
   statements;
   recursive_func ([actual argument])
}
```

Flow chart for Recursion

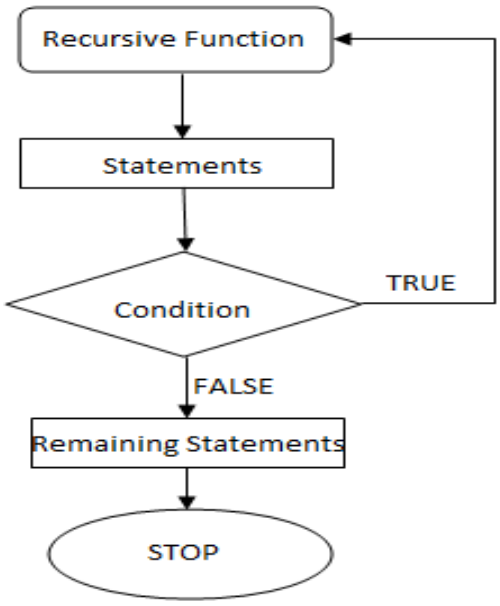


Fig: Flowchart showing recursion

DIRECT Vs INDIRECT RECURSION

There are two types of recursion, direct recursion and indirect recursion.

1. Direct Recursion

A function when it calls itself directly is known as Direct Recursion.

Example of Direct Recursion

```
#include<iostream>
using namespace std;
int factorial (int n)
{
   if (n==1 || n==0)
      return 1;
   else
      return n*factorial(n-1);
}

int main()
{
         int f = factorial(5);
         cout << f;
}
```

2. Indirect Recursion

A function is said to be indirect recursive if it calls another function and the new function calls the first calling function again.

Example of Indirect Recursion

```
#include<iostream>
using namespace std;
int func1(int);
int func2(int);
int func1(int n)
{
   if (n<=1)
      return 1;
   else
      return func2(n);
}
int func2(int n)
{
   return func1(n-1);
}
int main()
{
         int f = func1(5);
         cout << f;
}
```

Here, recursion takes place in 2 steps, unlike direct recursion.

- First, *func1* calls *func2*
- Then, *func2* calls back the first calling function *func1*.

Disadvantages of Recursion

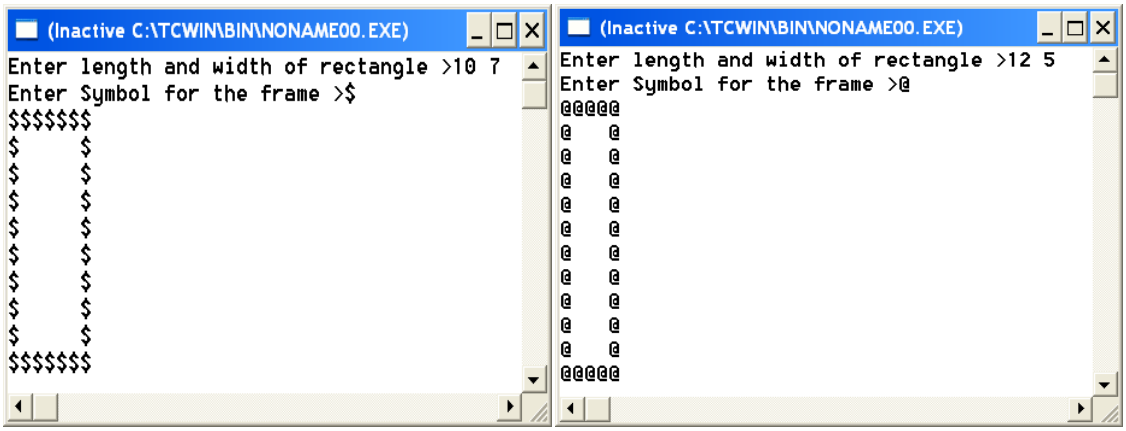
- Recursive programs are generally slower than non recursive programs. This is because, recursive function needs to store the previous function call addresses for the correct program jump to take place.
- Requires more memory to hold intermediate states. It is because, recursive program requires the allocation of a new stack frame and each state needs to be placed into the stack frame, unlike non-recursive(iterative) programs.

EXERCISE

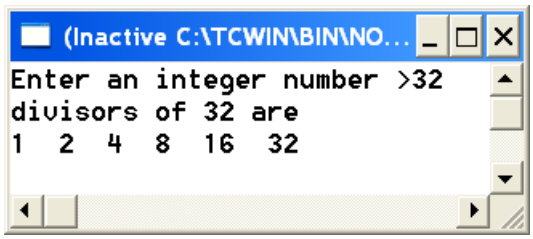
```
//draws a rectangle using functions
#include <stdio.h>
#include <iostream>
using namespace std;
void draw_solid_line(int size);
void draw_hollow_line(int size);
void draw_rectangle(int len, int wide);

int main(void) {
   int length, width;

   cout<<"Enter length and width of rectangle >";
   cin>>length;
   cin>>length>>width;

   draw_rectangle(length, width);

   system("pause");
   return 0;
}
void draw_solid_line(int size) {
    //Write your Code Here
}
void draw_hollow_line(int size) {
    //Write your Code Here
}
void draw_rectangle(int len, int wide) {
    int i;
    draw_solid_line(wide);
```

```
    if (len > 2) {
      for (i=1; i<=len - 2; i++)
        draw_hollow_line(wide);
    }
    draw_solid_line(wide);
}
```

1. Modify above code to get following output. (Optional Question)



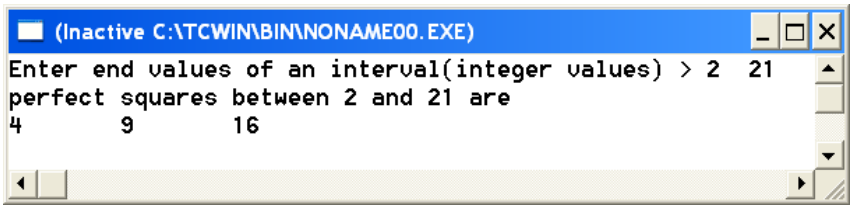
2. Write function divisors that receive an integer number and return its divisors using pointer array on main including 1 and itself.



3. Write a logical function perfect_Square that receives a positive integer number and checks if it is a perfect square or not. (Optional Question)

Note: perfect square numbers are 4, 9,16,25,36 etc….

Write a main function that makes use of the perfect_Square function to find and print all perfect squares between n1 and n2. n1 and n2 are end values of a range introduced by the user.

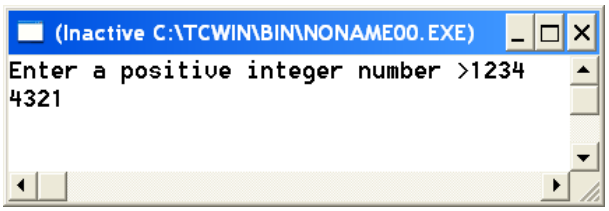


4. Write a logical function, is_prime, that takes an integer number and determines if the number is prime or not.
Note: A prime number is one that does not have proper factors.
Write a main function that makes use of the is_prime function to find and print all the prime numbers from 2 to 100.

5. Write a program that computes the area and perimeter of a rectangle using 2 functions. One function is used to read the width and length, and the other to compute the area and perimeter. Write a main function to test your functions. (Optional Question)

6. Write a function that receives a time in seconds and returns the equivalent time in hours, minutes, and seconds. Write a main function to test your function. For example if the received time is 4000 seconds, the function returns 1 hour, 6 minutes, and 40 seconds.
Use integer division and remainder.

7. Write a recursive function that receives a positive integer number and prints it on the screen in reverse order as shown below. Write a main function for testing. (Optional Question)



8. Write a recursive function countdigits that receives an integer number and returns how many digits it contains. Write a main function to read an integer number and tests the written function countdigits.
Input: 12345
Output: 5 Digits

9. Write a function that reverses the elements of an array. In other words, the last element must become the first; the second from last must become the second and so on. The function must accept only one pointer value and return void. (Optional Question)

10. Write a program that will read 10 integers from the keyboard and place them in an array.
The program then will sort the array into ascending and descending order and print the sorted list.
The program must not change the original array or create any other integer arrays.
Hint: It requires two pointer arrays.