Lecture 4 – Pointers - Structures - Header files

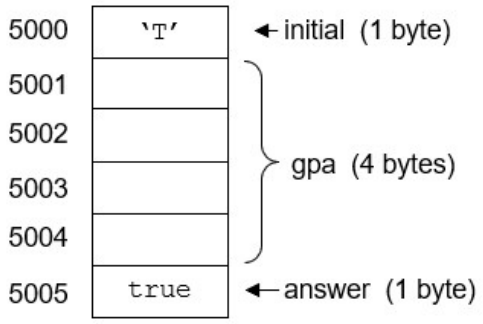
Pointers - A pointer can only hold a memory address – never a value.

- A pointer is a variable that holds an address of another variable.

Memory Address - Each memory location holds one byte and has a unique numerical address.

- Each byte of a variable has an address.

Ex:
```
char initial = 'T';
float gpa;
bool answer = true;
```

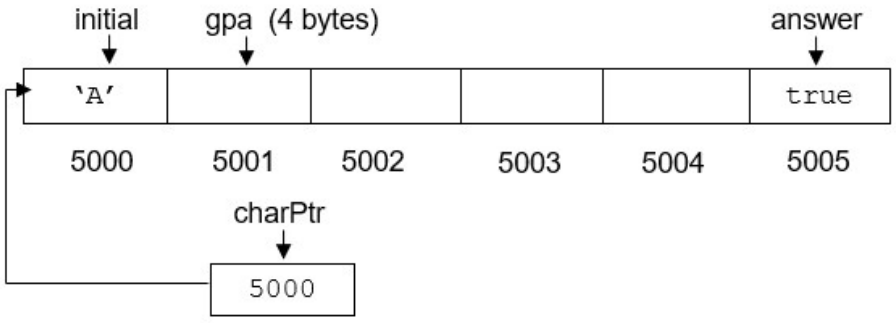


To declare a pointer:

```
char  *ptr;          // Declares a pointer variable.
                     // The pointer points to variables of char data type.
                     // An asterisk must be in front of each pointer variable.

float *floatPtr;
char* charPtr;       } All of these declarations are OK.
string * strPtr;
```

Address Operator: & - Use the & operator to assign a memory address to a pointer.

Ex #:
```
char    initial;          // Declare a variable of char data type.
char    *charPtr;         // Declare a pointer
charPtr = &initial;       // Assign the address of initial to charPtr.
```



Note: To initialize a pointer: `char *charPtr = &initial;`

Note: An address held in one pointer can be assigned to another pointer, providing they are of the same data type.

De-reference Operator (*) - (also called **indirection operator**)

- When a pointer points to a variable, the value held in the variable can be accessed (de-referenced), by using the de-reference operator (*).

Ex #:
```
double deposit;     // Declare a variable of double data type.
double * ptr;       // Declare a pointer that points to variables of double type

ptr = & deposit;    // Assign the address of number to the pointer.

* ptr = 1050.0;     // Assigns 1050.0 to number.
```

Ex #:
```
cout << deposit;    // Output: 1050.0
cout << *ptr;       // Outputs the value in the variable pointed to
                    //    by ptr (which in this case is 1050.0)
```

Ex #:
```
int num1;                   // Declare an int variable.
int * ptr = & num1;         // Declare a pointer and assign the address
                            //    of number to ptr.
int * temp;                 // Declare a pointer that points to int variables.
temp = ptr;                 // This works because they are both int pointers.

float * amtPtr;             // Declare a pointer that points to float variables.
amtPtr = ptr;               // Error – different data types.
```

Pointers, Arrays, and Pointer Arithmetic

- Assign a pointer to the first element in an array.
- Access array elements by incrementing the pointer.

Ex #:
```
int main()
{
   const int SIZE = 5;
   int numbers [SIZE] = {6, 8, 9, 3, 7};
   int *ptr;

   ptr = numbers;      ← Assigns the address of numbers[0] to ptr.

   for (int i=0; i<SIZE; i++)
   {
      cout << *ptr << endl;
      ptr++;           ← Increments the address of numbers[0]
   }                        to numbers [1].
  return 0;                 (Therefore, the address is incremented
}                           by 4, because integers are 4 bytes.)
```

No **&** when assigning a array address.

Pointers as function parameters

- A pointer can be used as a function parameter.

- When a pointer is passed to a function, the pointer holds an address of a variable that can then be accessed by the function.
- A pointer gives a function access to the original variable, much like a reference variable does.
  Note: When a variable is passed by reference, the reference variable acts as an alias to the original variable. This gives the function access to the original variable.
- Generally, passing reference variables is easier than passing pointers as arguments.
  - However, pointers to c_strings work well and are easy.

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

void getName(char *);
void displayName(char *);

const int SIZE = 30;

int main()
{
   char name[SIZE];
   char * ptr = name;          ← The address of the first byte of the array is
                                  assigned to the pointer.
   getName(ptr);
   displayName(ptr);

   return 0;
}
// ----------------------------------
void getName(char * pName)
{
   cout << "Enter name:  ";
   cin.getline(pName, SIZE);
}
// ----------------------------------
void displayName(char * pName)
{
   cout << "Hi " << pName << ".\n";
}
// ----------------------------------
```

```
/* OUTPUT:

Enter name:  Tom Lee
Hi Tom Lee.

Press any key to continue */
```

struct (structures) - A structured data type.
- A collection of components referred to by a single name.
- class and struct are two structured data types (classes later).

struct – Reserved word for structure.

- **Object** - A struct variable is called an object.
- **struct** – A data type in which each object is a collection of components, called data members.

Data members of a struct object are **public**. (Class data members are **private** by default).

- **public** – Means that any function has access to the object's data members.
- **private** – Means only member functions can have access to data members.
  - Private data members are more secure.

General convention: Use structs when there are no member functions.

Use classes when there are member functions.

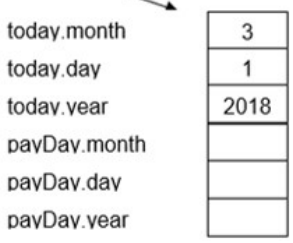
To define a structure:

Ex #:
```
struct Time          //  Identifier starts with uppercase letter
{
   int hours;
   int minutes;
   int seconds;
};                   //  Semicolon is required
```

Ex #: **Using a struct in a program**

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


struct Date          // The data type is Date.
{                    // The struct can be defined before main, but usually in a header file.
  int month;         // Memory is not allocated when the struct is defined.
  int day;
  int year;          // month, day and year are data members of struct Date.
};

int main()
{
  Date today = {3,1,2018};      //  Use an initialization list to initialize data members.
  Date payDay;                  //  Variable declarations, just like other data types.
                                //      today and payDay are variables of type Date
```

Space is allocated in memory when variables (objects) are declared



Dot notation – Another way to assign values to a struct object is to use the Dot Operator (**.**)

```
payDay.month = 3;
payDay.day = 1;
payDay.year = 2010;
```

```
cout << "Enter today's date (mmddyy):  "
cin >> today.month >> today.day          // cin >> Date; ←Wrong
    >> today.year;

if (((today.month == payDay.month) &&
     (today.day == payDay.day)) &&
     (today.year == payDay.year)))
{
    cout << "Today is pay day!";
}
```

Pass a struct object to a function by reference.

- The memory address of the first byte of the struct object is passed.

Ex #:

```
void getDate(Date & date);

int main()
{
   Date today;

   getDate(today);
   return 0;
}
-------------------------
void getDate(Date & date)
{
   cout << "Enter the date (mmddyy):  "
   cin >> date.month >> date.day >> date.year;
}
```

---

2 ways to access the individual data members: (see struct Box below)

1. **Dot operator**

Ex #:

```
Box tackleBox; // Declare a box object  (see struct Box)
tackleBox.width = 10;
```

2. **Arrow Operator** - Use a **pointer** with the arrow operator to access an object's data members

   - The Arrow Operator consists of a hyphen (-) and a greater-than symbol (>).

Ex #:

```
Box shoeBox;          // Declare a box object  (see struct Box)
Box  *ptr;            // Declare a pointer that points to Box objects
ptr = & shoeBox       //  Assign the address of shoeBox to ptr.
```

```
ptr -> width = 10;     //  arrow operator to access shoeBox.width
```

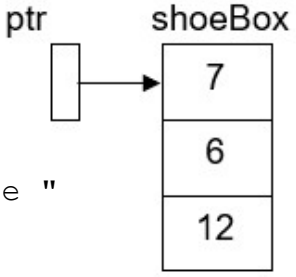
// Use the following struct with the program on the next page.

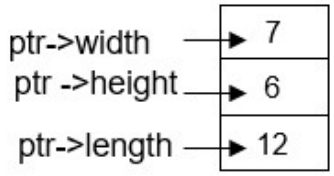
```
struct Box
{
   int width;
   int height;
   int length;
};

int main()
{
    Box * ptr;
    Box  toolBox = {9, 12, 18};
    Box  shoeBox = {7,6,12};

    ptr = & shoeBox;

    cout << "The dimensions (W-H-L) of the tool box are "
         << toolBox.width << " - " << toolBox.height
         << " - "<< toolBox.length << endl << endl;

    cout << "The dimensions (W-H-L) of the shoebox are "
        << ptr ->width << " - " << ptr ->height
        << " - "<< ptr ->length;
    return 0;

}
```

// Declare a pointer that can hold
// the address of a Box object.

// Declare two objects of Box type

// Assign the address of *shoeBox*
// to *ptr*.






```
/* OUTPUT

The dimensions (W-H-L) of the tool box are 9 - 12 - 18
The dimensions (W-H-L) of the shoebox are 7 - 6 - 12

Press any key to continue  */
```

Constructor function - A struct specification can include a constructor.

- A constructor is a function with the same name as the struct itself.
- A constructor allows a struct object's data members to be initialized at the time the object is declared.

Ex #: Because of the constructor below, when a Box object is declared, its data members are assigned zeros.

```
struct Box
{
```

```
        int width;
        int height;
        int length;

        // Constructor
        Box()
        {
           width = 0;
           height = 0;
           length = 0;
        }
    };
```

Array of struct objects - A list of struct objects (records) can be held in an array.

- Each array element holds one struct object.

```
struct Record
{
   string name;
   int age;
};

const int SIZE = 5;

int main()
{
    Record records[SIZE];

    for (int i = 0;  i < SIZE;  i++)
    {
       cout << "AGE:  ";
       cin >> records[i].age;
       cin.ignore();
       cout << "NAME:  ";
       getline(cin, records[i].name);      // string type
```

Header Files – Programmer-defined header files can be used to hold C++ declarations of constants, function prototypes / implementations and class specifications, etc.

#include <iostream> - **#include** is a directive to the preprocessor to insert the contents of the iostream header file.

Ex: Create a header file and name it: **Box.h**

- A new header file can be created the same way as a new .cpp file, except select **C++ Header File** instead of C++ Source File.

Place the struct Box specification in the file.

Then include the following preprocessor directive: Enclose in quotes

```
#include "Box.h"
```

```
int main()
```