C++ For C Coders 5

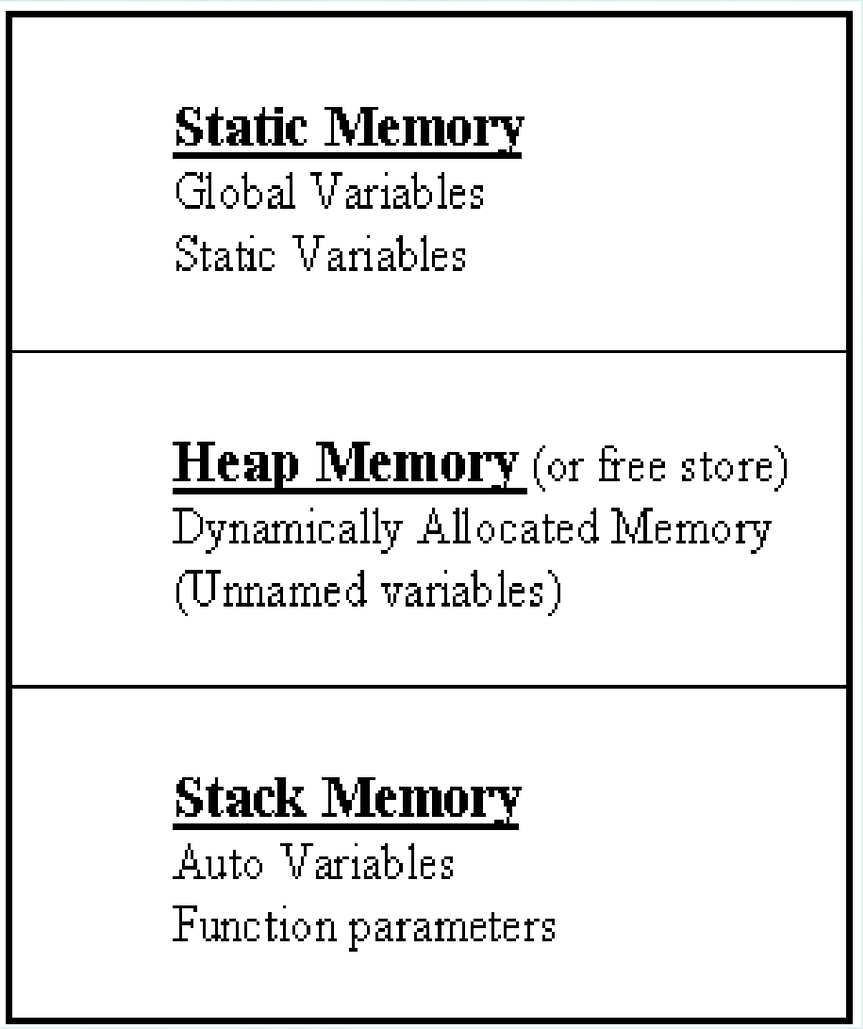
Data Structures
C++ for C Coders

한동대학교 김영섭교수
idebtor@gmail.com

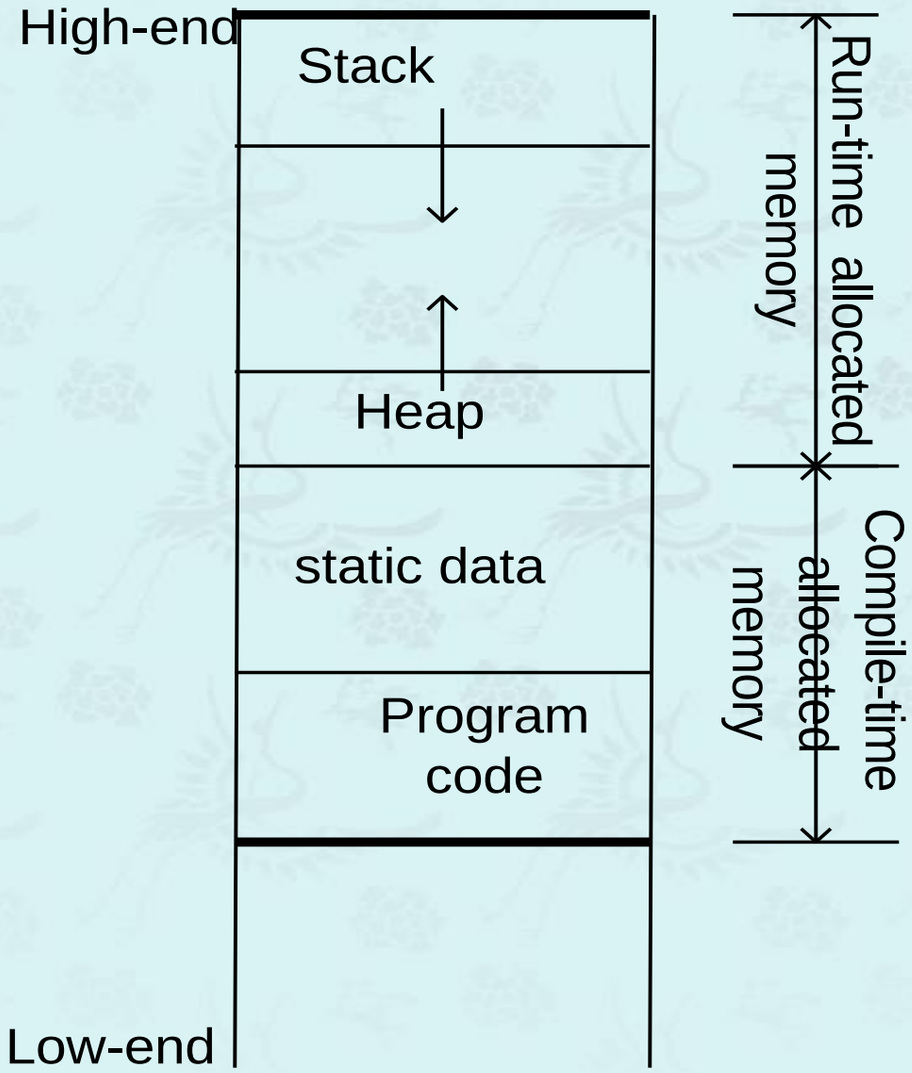
dynamic memory allocation
new & delete operators

Three kinds of memory (or data)

- **Static memory**
  - where global and static variables live
  - allocated at compiler time
- **Heap memory**
  - dynamically allocated at execution time
  - "managed" memory accessed using pointers
  - explicitly allocated and deallocated using operators new and delete by programmer
- **Stack memory**
  - used by automatic variables
  - automatically created at function entry, resides in activation frame of the function, and is destroyed when returning from function



Dynamic Memory Allocation Diagram



Dynamic Memory Allocation

- *In C*, functions such as **malloc()** are used to dynamically allocate memory from the **Heap**.

- *In C++,* this is accomplished using the **new** and **delete** operators

- **new** is used to allocate memory during execution time
  - returns a pointer to the address where the object is to be stored
  - always returns a pointer to the type that follows the **new**

Operator new Syntax

new DataType

new DataType[IntialExpression]

- If memory is available, in an area called the heap (or free store) **new** allocates the requested object or array, and returns a pointer to (address of) the memory allocated.
- Otherwise, program terminates with error message.
- The dynamically allocated object exists until the **delete** operator destroys it.

Operator new

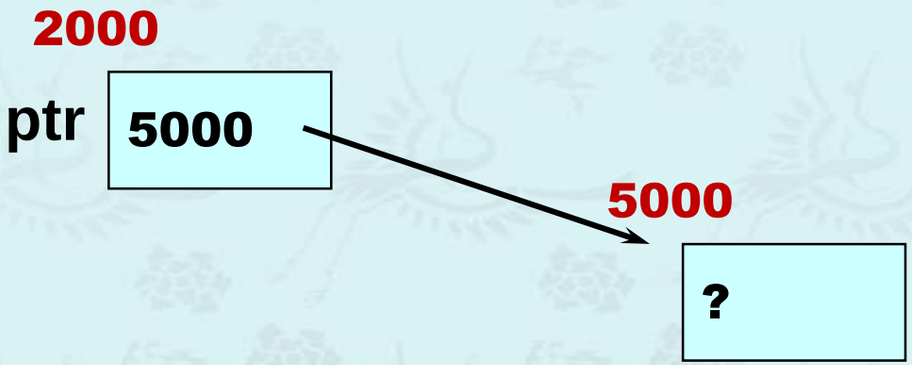
```
char  *ptr;



ptr = new char;

*ptr = 'B';

cout  <<  *ptr;
```



NOTE: **Dynamic data has no variable name**

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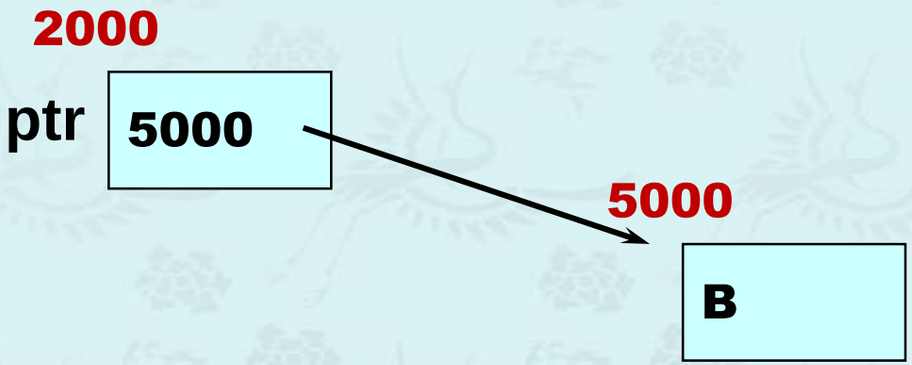


NOTE: **Dynamic data has no variable name**

new vs. malloc()

- new is an operator.
- It calls the constructor.
- It returns exact data type if memory is available.
- It throws bad_alloc exception on failure. Use **nothrow** for **nullptr**.
- It can be overridden.
- In which memory allocated from the heap.
- Size is calculated by the compiler.

- malloc is a library function.
- It does not call the constructor.
- It returns the void * if memory is available.
- It returns `nullptr` on failure.
- It cannot be overridden.
- In which memory allocated from the heap.
- Need to pass the size.

NOTE: Use **malloc()** only if asked. Use **new** and **delete** operators in this course.

Dynamic Memory Allocation

- *In C*, functions such as **malloc()** and **free()** are used to dynamically allocate and deallocate memory from the **Heap**.

- *In C++,* this is accomplished using the **new** and **delete** operators

- **new** is used to allocate memory during execution time
  - returns a pointer to the address where the object is to be stored
  - always returns a pointer to the type that follows the **new**

The NULL/nullptr Pointer

- There is a pointer constant called the "null pointer" denoted by NULL/nullptr.
- NULL is int type 0 in C/C++, but nullptr is std::nullptr_t type.
- NOTE: It is an error to dereference a pointer whose value is NULL or nullptr. Such an error may cause your program to crash, or behave erratically. It is the programmer's job to check for this.

```
while (ptr != nullptr) {
      . . .
         . . .              // ok to use ptr here
}
```

Operator delete Syntax

```
delete PointerVariable
```

```
delete [] PointerVariable
```

- The object or array currently pointed to by Pointer is deallocated, and the value of Pointer is undefined. The memory is returned to the free store.
- Good idea to set the pointer to the released memory to nullptr.
- Square brackets are used with delete to deallocate a dynamically allocated array.

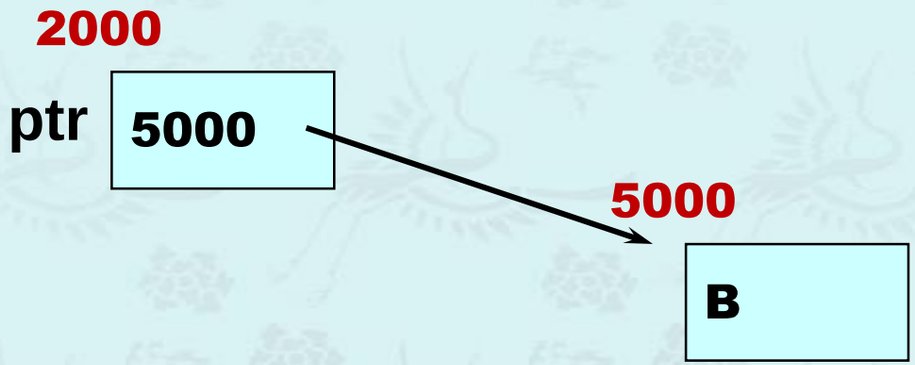
Operator delete

```
char  *ptr;


ptr = new char;

*ptr = 'B';

delete ptr;
```



NOTE: **delete** deallocates the memory pointed to by ptr

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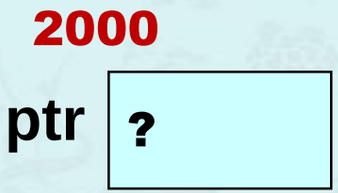
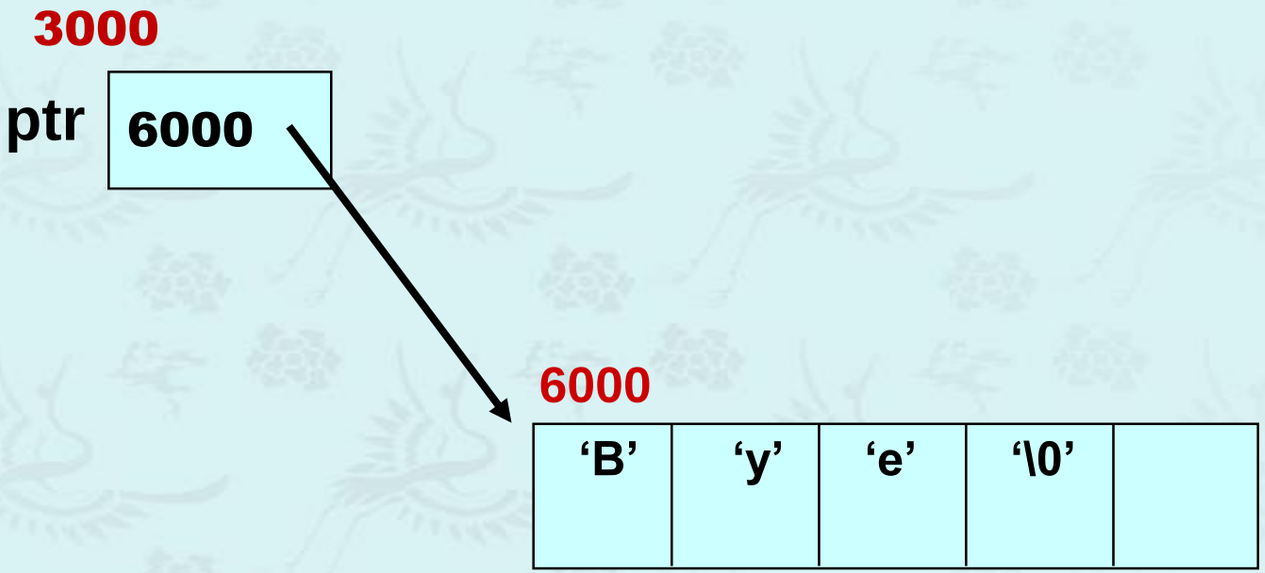


NOTE: **delete** deallocates the memory pointed to by ptr

Example: Operator delete

```
char  *ptr;

ptr = new char[5];

strcpy(ptr, "Bye");

ptr[0] = 'E';

delete [] ptr;

ptr = nullptr;
```



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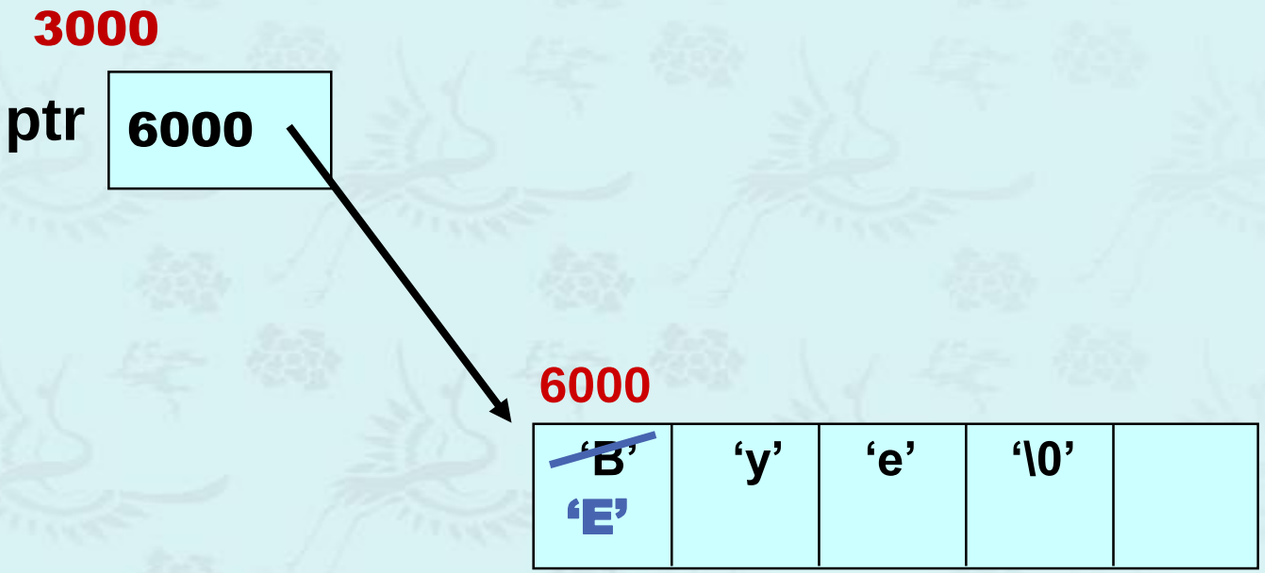

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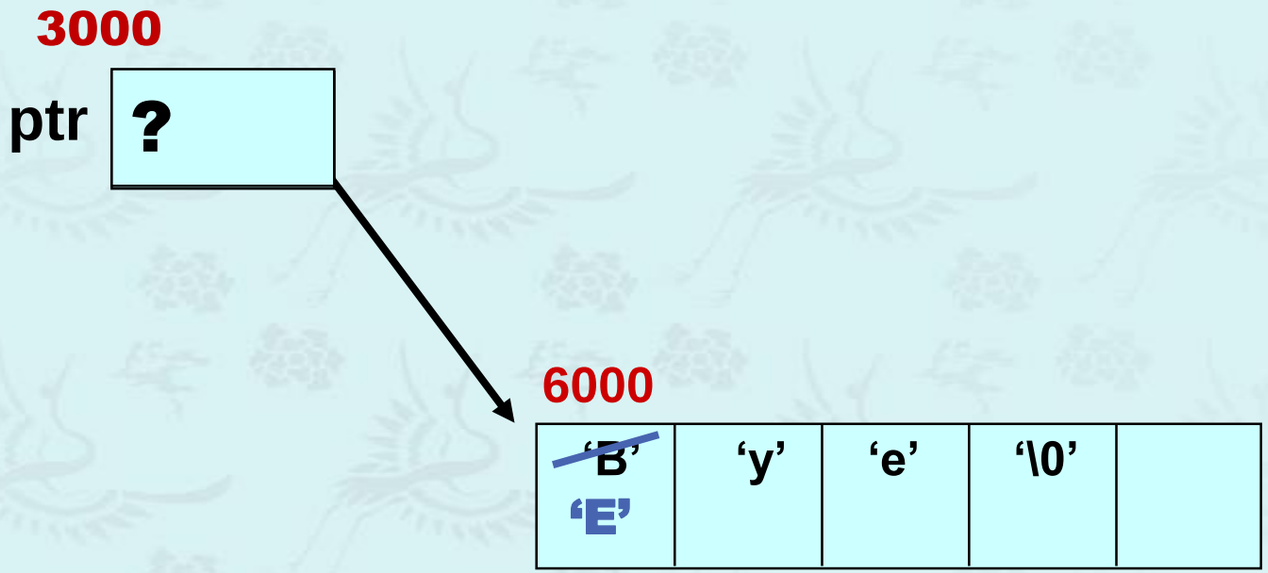

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- deallocates the array pointed to by ptr
- ptr itself is not deallocated
- the value of ptr becomes undefined

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Take Home Message

- Be aware of where a pointer points to, and what is the size of that space.
- Have the same information in mind when you use reference variables.
- Always check if a pointer points to nullptr before accessing it.
  For example,

```
char *ptr = new char[5];
assert(ptr != nullptr);
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- Be aware of where a pointer points to, and what is the size of that space.
- Have the same information in mind when you use reference variables.
- Always check if a pointer points to nullptr before accessing it.
  For example,

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char *ptr = new char[5];
assert(ptr != nullptr);
```

```
char *ptr = new (nothrow) char[5];
assert(ptr != nullptr);
```

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