

# C++ For C Coders 5

**Data Structures**  
**C++ for C Coders**

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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

## **Static Memory**

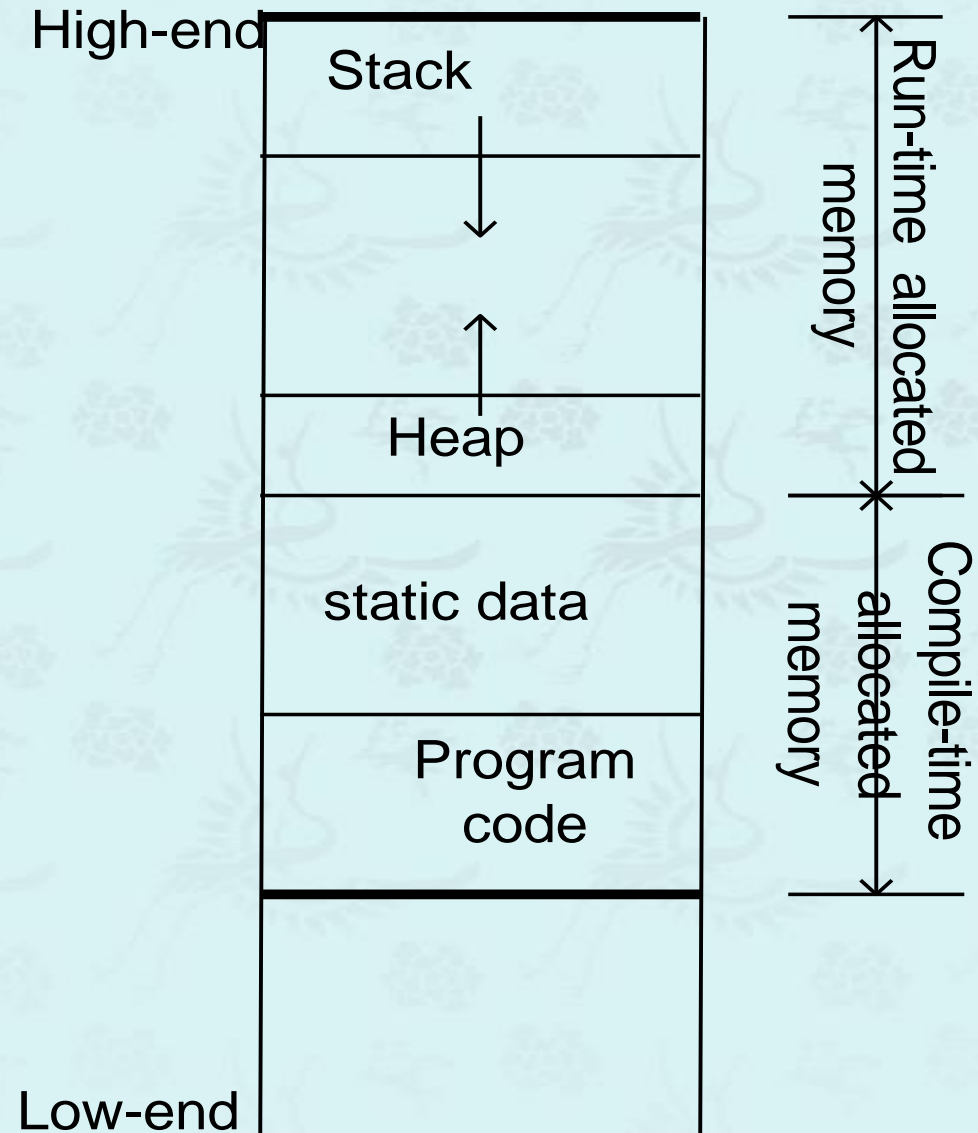
Global Variables  
Static Variables

**Heap Memory** (or free store)  
Dynamically Allocated Memory  
(Unnamed variables)

## **Stack Memory**

Auto Variables  
Function parameters

# Dynamic Memory Allocation Diagram



## Dynamic Memory Allocation

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- *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

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**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**

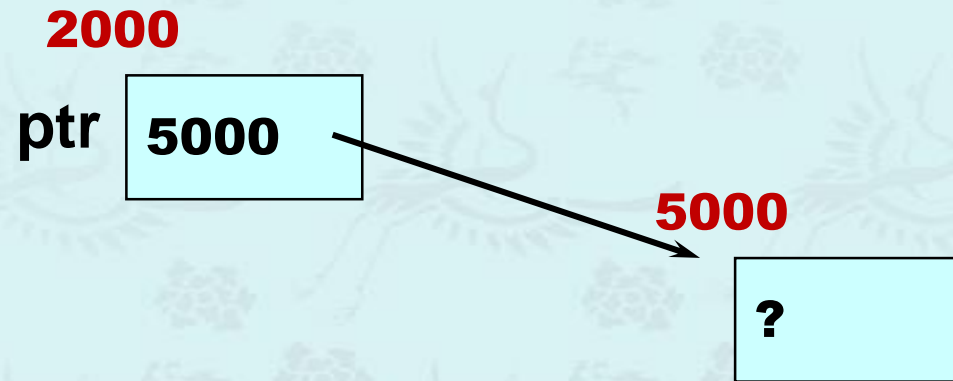
```
char *ptr;
```

➔ 

```
ptr = new char;
```

```
*ptr = 'B';
```

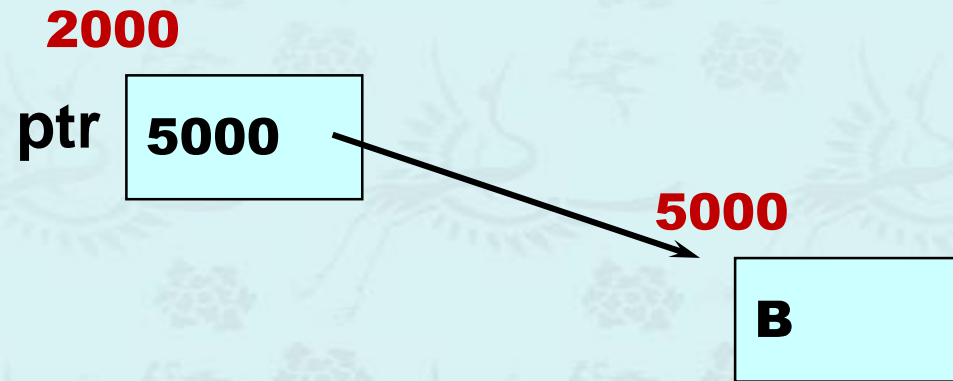
```
cout << *ptr;
```



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

## Operator **new**

```
char *ptr;  
  
ptr = new char;  
  
➔ *ptr = 'B';  
  
cout << *ptr;
```



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

## new vs. malloc()

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- **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: We learn how to use both `malloc()` as well as `new` first. Once we get familiar with them, then we rather start using **new** and **delete** operators **more and more later** in this course.



# Dynamic Memory Allocation

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- *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
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## The NULL/nullptr Pointer

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- 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

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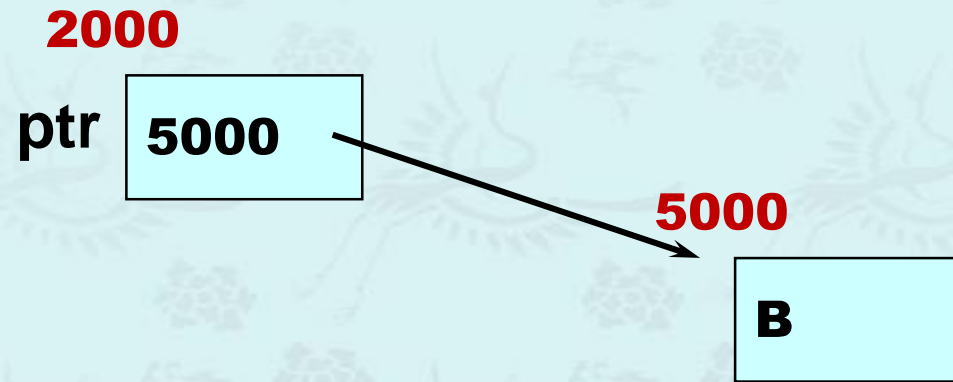
```
delete PointerVariable
```

```
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

## Operator **delete**

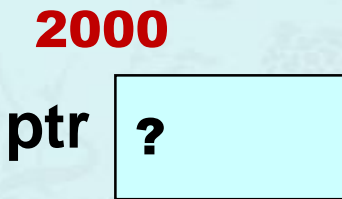
```
char *ptr;
```

```
ptr = new char;
```

```
*ptr = 'B';
```

➔ 

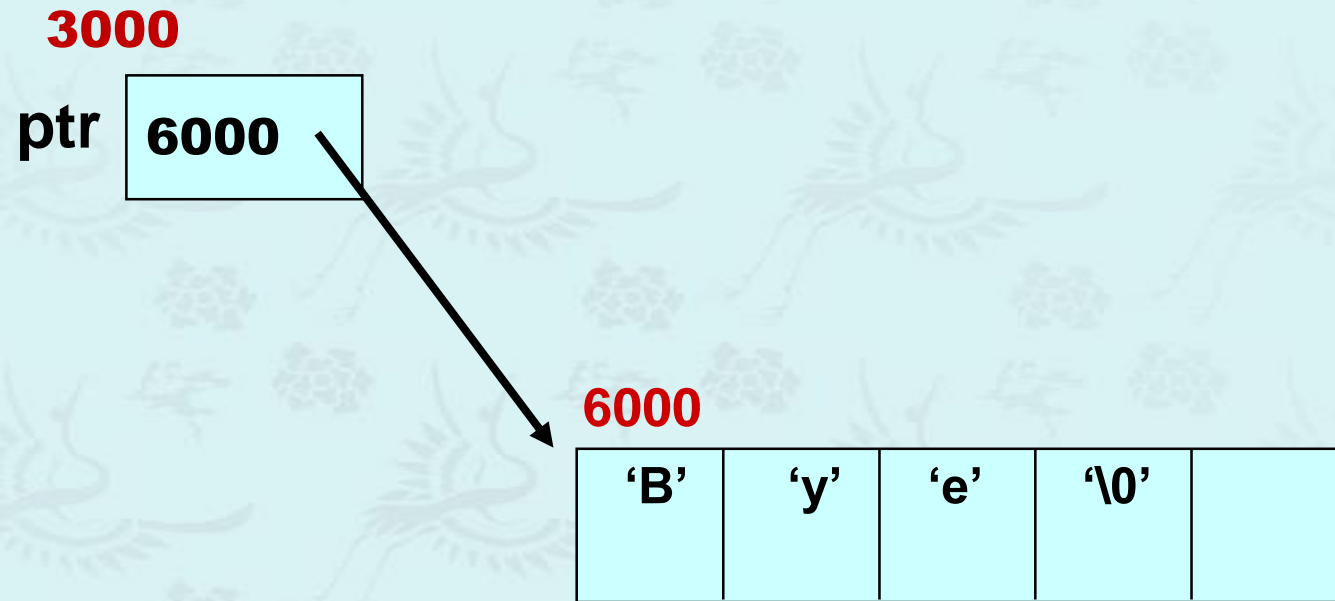
```
delete ptr;
```



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

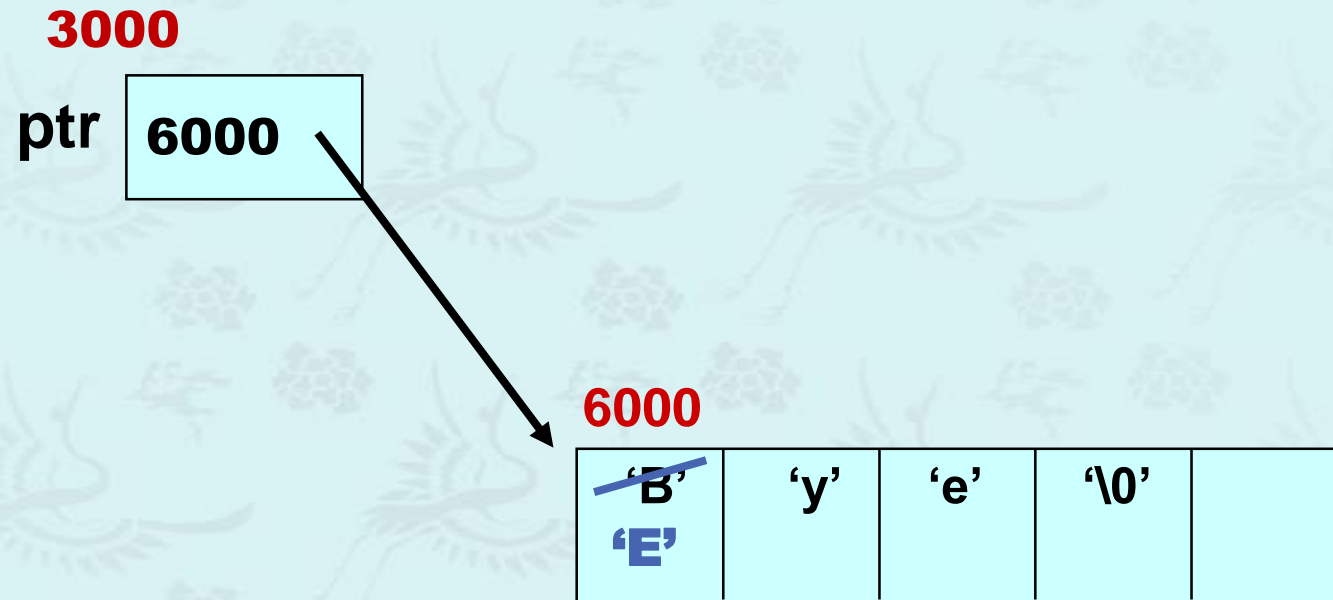
## Example: Operator **delete**

```
char *ptr;  
  
ptr = new char[5];  
  
➔ strcpy(ptr, "Bye");  
  
ptr[0] = 'E';  
  
delete [] ptr;  
  
ptr = nullptr;
```



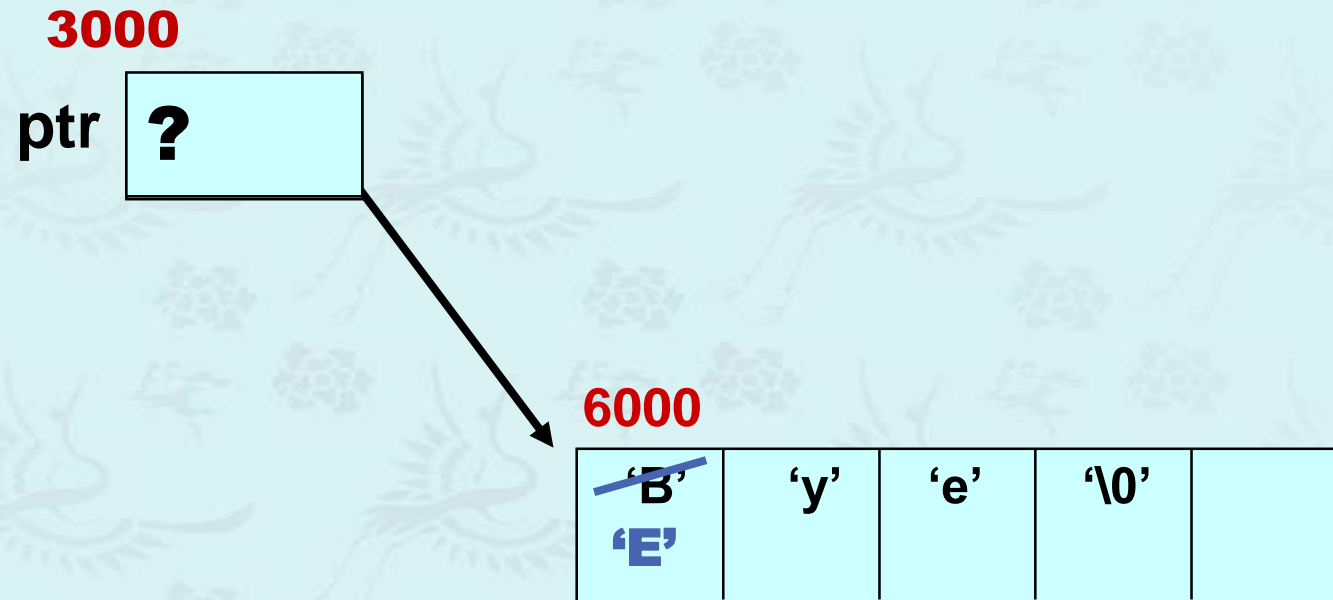
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→ ptr[0] = 'E';  
  
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## Example: Operator **delete**

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```



### NOTE:

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



## Example: Operator **delete**

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char *ptr;  
  
ptr = new char[5];  
  
strcpy(ptr, "Bye");  
  
ptr[0] = 'E'  
  
delete [] ptr;  
  
→ ptr = nullptr;
```

**3000**

**ptr** **NULL**

### **NOTE:**

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

## Take Home Message

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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,

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



## Take Home Message

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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,

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



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

## Quiz 1

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

int main() {
    int *pi;
    *pi = 17;
    cout << "i = " << *pi << endl;
    return 0;
}
```

- What type of an error?
  1. a link error
  2. a run-time error
  3. a syntax error
  4. a logic error
- Fix the code such that it outputs "i = 17".
  1. Adding two lines
  2. Using new and delete

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