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Pointers

In C++ you can “dynamically allocate” memory. That means that at any point in your program execution you can specially request space to store new variables. Unlike variables declared on the stack, a variable stay allocated until the programmer explicitly releases or “frees” it.

The mechanism for accessing such memory is through pointers: special variables that store memory addresses. When one requests dynamically allocated memory, a pointer is returned.

### Dynamic Allocation

There are two ways to request memory: you can ask for a single variable or you could ask for an array of variables:

Point \* pointAddress = new Point; // allocates a single “point”

Point \* pointArray = new Point[3]; // allocates 3 points.

And here is a picture of what happens in memory. pointAddress stores the address of its pointee:

**Heap**

**Stack**

68

40

pointAddress

pointArray

1242

92

213

0

546

246

3

0

654

40

44

48

52

56

60

64

68

72

pointArray[0]

pointArray[1]

pointArray[2]

pointAddress->y

pointAddress->x

In this simple memory picture, each bucket of memory on the heap has an address (valued 40 through 72). Each allocated point gets two buckets (for the x and y components). The pointers pointAddress and pointArray are variables that live on the stack and hold addresses of memory on the heap.

### Pointer Types

We have just introduced a new variable type. The “pointer”. It is a stack variable that stores an address. You can tell a variable is a pointer if its type ends with a \*.

|  |  |
| --- | --- |
| **Type** | **Meaning** |
| int \* | Address of an int |
| Point \* | Address of a point |
| Set<int> \* | Address of a Set<int> |

### Accessing Pointees

Pointees is the name of the variables that pointers store the address of. We would like to be able to get and set their values.

**Single variable dynamic allocation:**

If a class or struct was dyammically allocated, we can apply the -> operator to its pointer to access the pointee’s members values or to call methods on the pointee.

pointAddres->x = 5; // makes the pointee x = 5

cout << pointAddress->y; // gets the pointeee y

**Array dynamic allocation:**

If an array of pointees were created, you can get the ith value using bracket notation.

pointArray[0].x = 5 // sets the x value of the first element

cout << pointArray[1].y; // gets the y value of the second element

### Assignment

You can use the = operator to copy a pointers address. Then two pointers point to the same pointee. This is called “sharing”.

Point \* a = new Point; // allocates a single “point”

Point \* list = new Point[3]; // allocates 3 points.

Point \* b = a;

### Delete

When you use the new keyword to allocate memory, that memory persists until you tell the computer it can re-use it (or your program exits). To free the memory, use the keyword delete:

delete pointAddress; // how to delete a single variable

delete[] pointArray; // how to delete an array.

### Other Operators

There are a few other special operators that you can perform related to pointers. We don’t emphasize them in CS106B and you **won’t need to know them for the final**. I included them here for full measure.

|  |  |
| --- | --- |
| **Pointer Operator** | **Meaning** |
| & | Get the address of a variable |
| \* | Get the pointee on the other side of the pointer. |

Important: The \* operator is not to be confused with the **much more common** use of \* as part of a variable type name.

int stackInt = 5;

Point \* a = &stackInt; // a points to the address of stackInt

cout << \*a // prints 5