CENG 112 – Data Structures

Pointers and Arrays

Mustafa Özuysal
mustafaozuysal@iyte.edu.tr

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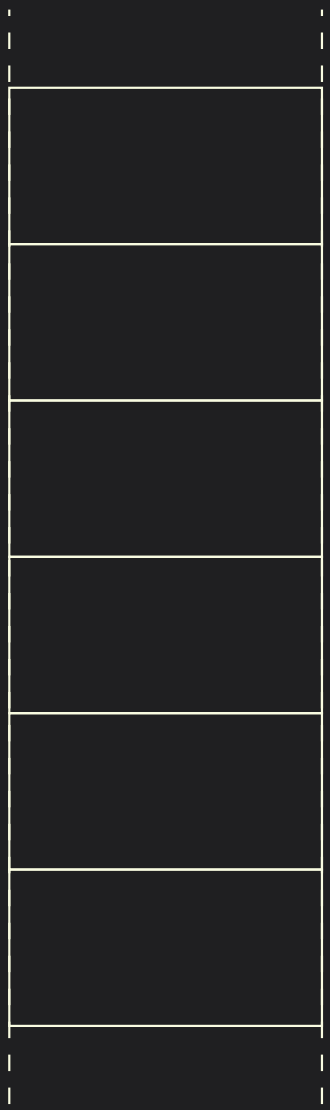
İzmir Institute of Technology

A Flat View of Computer Memory

The Memory



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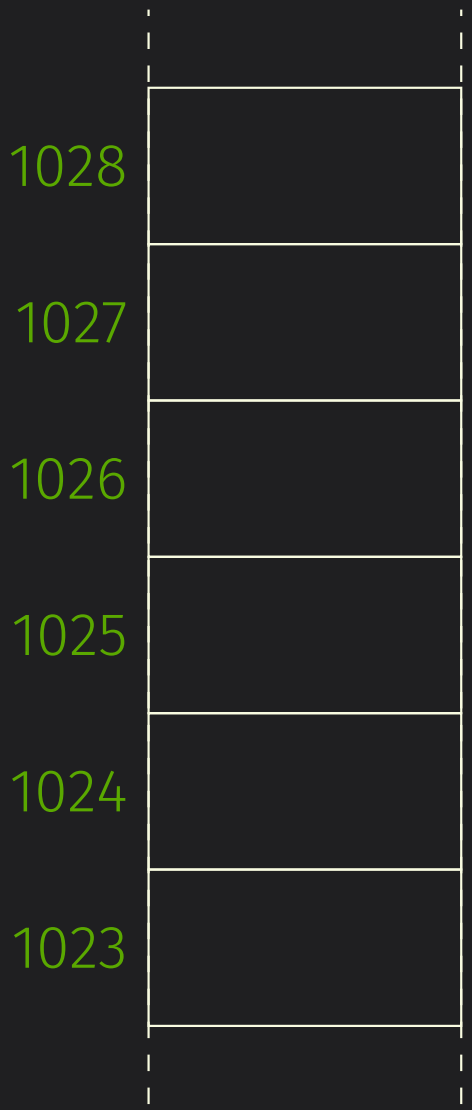

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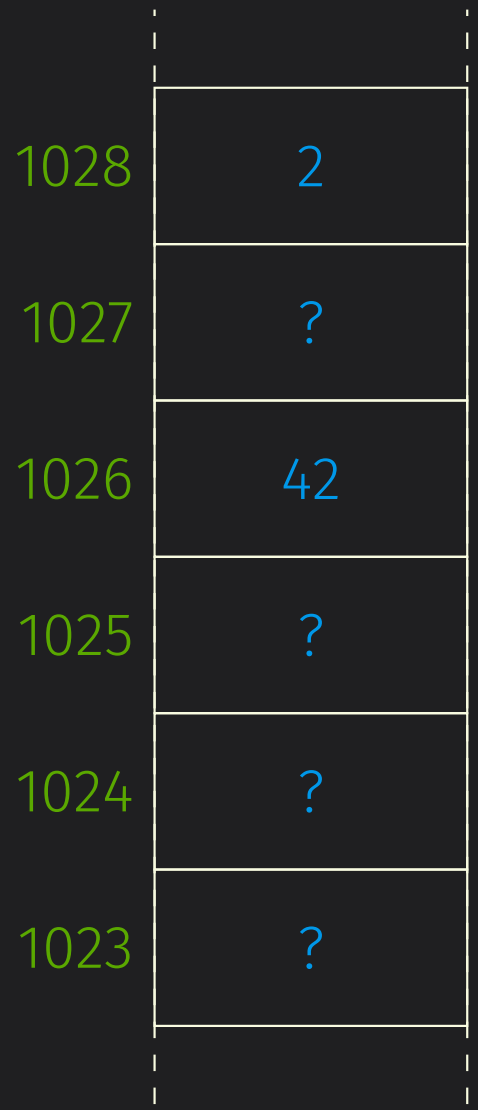

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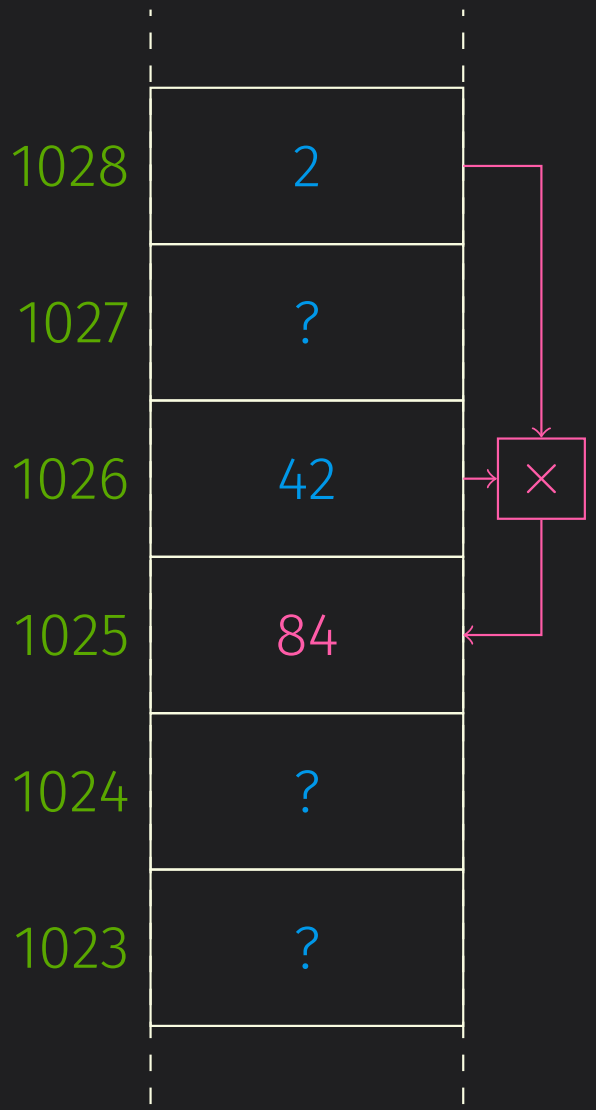

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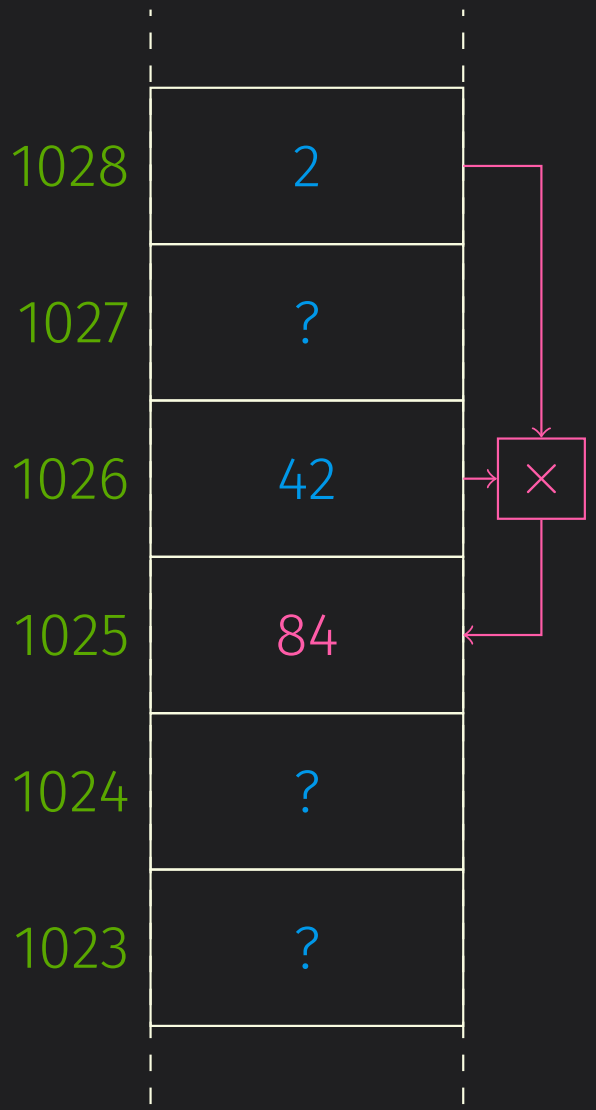

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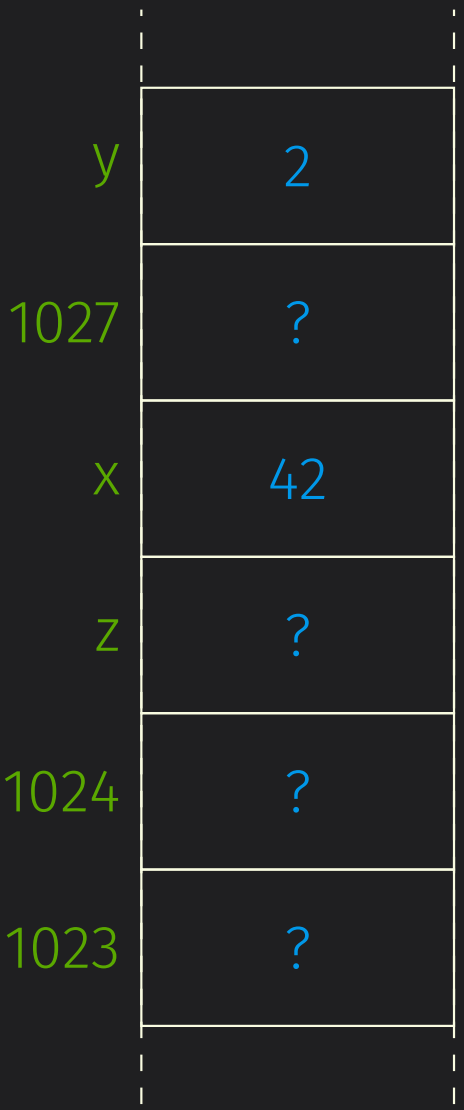
- Your program's data lives in these boxes.
- The Central Processing Unit (CPU) knows how to move and process the data in these boxes.
- Back in the old days, people had to program using addresses:

```
mul $1026,$1028,$1025
```

Variables



- Modern languages let us create variables that gets assigned to boxes by the compiler:

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1   int x = 42; int y = 2; int z;
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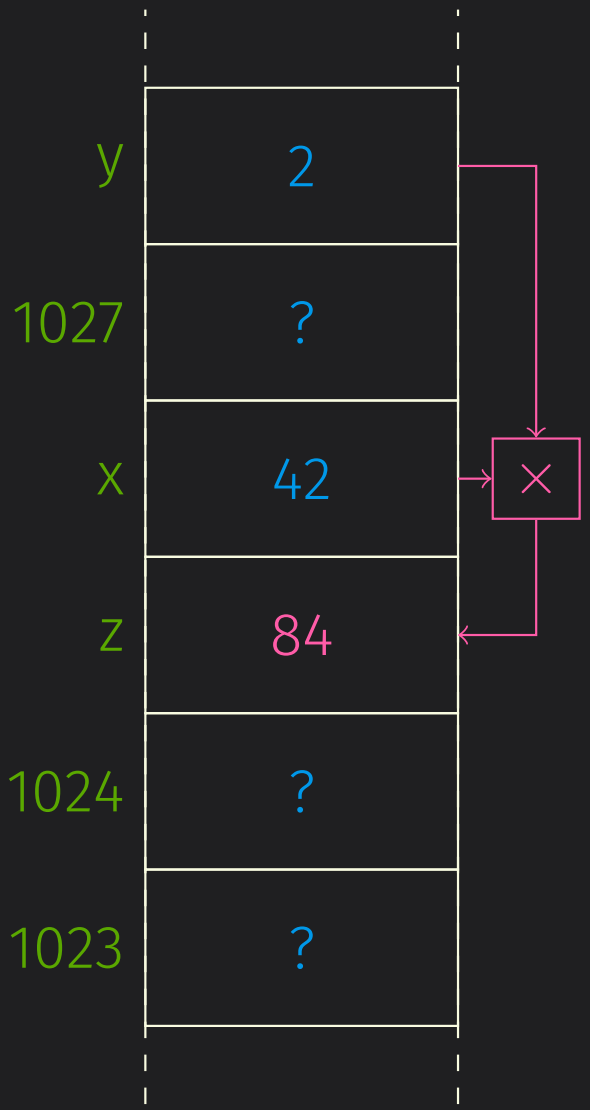

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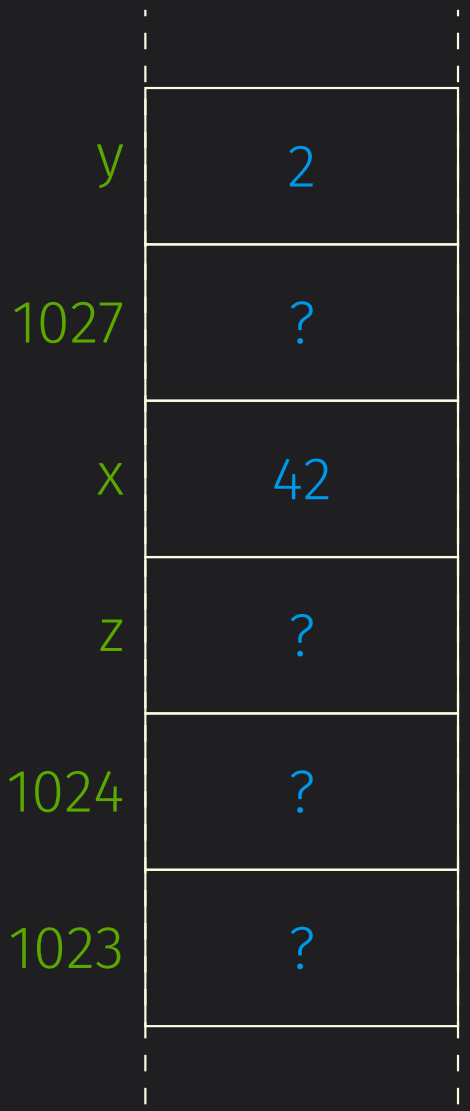
- When we write code operating on these variables, compiler and linker convert the variables to addresses automatically:

```
1   z = x * y;
```

Pointers



- We can get the address of a variable with the & operator.:

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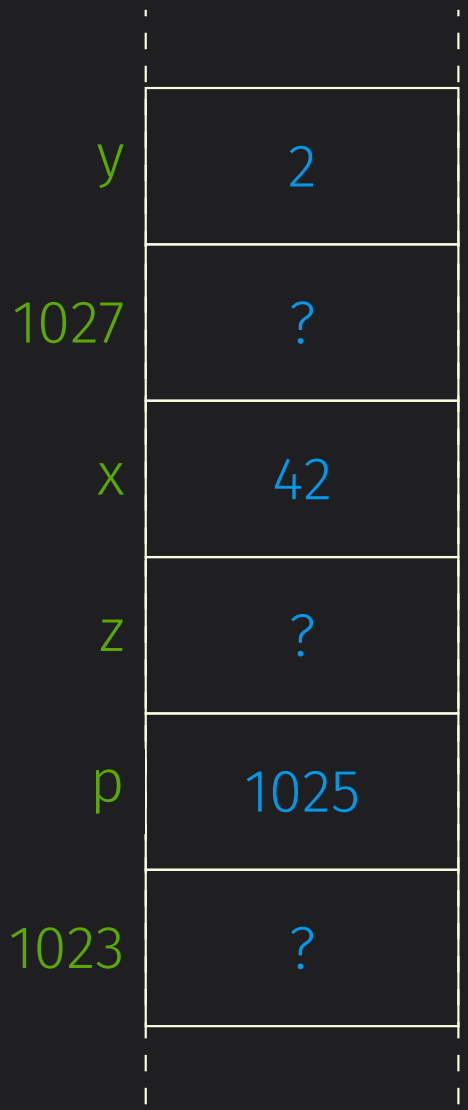
Pointers



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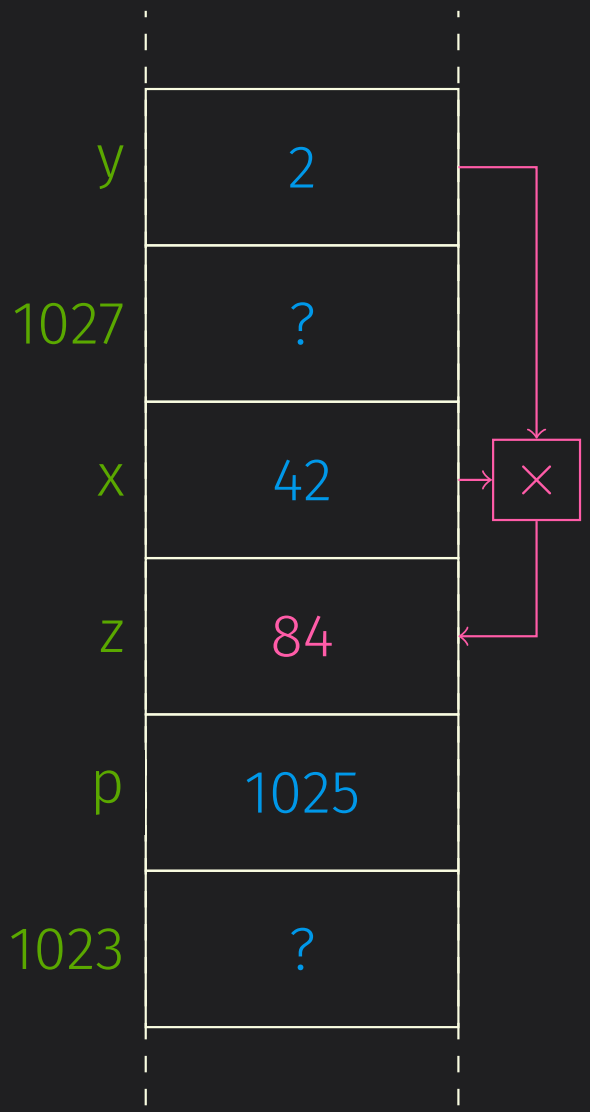

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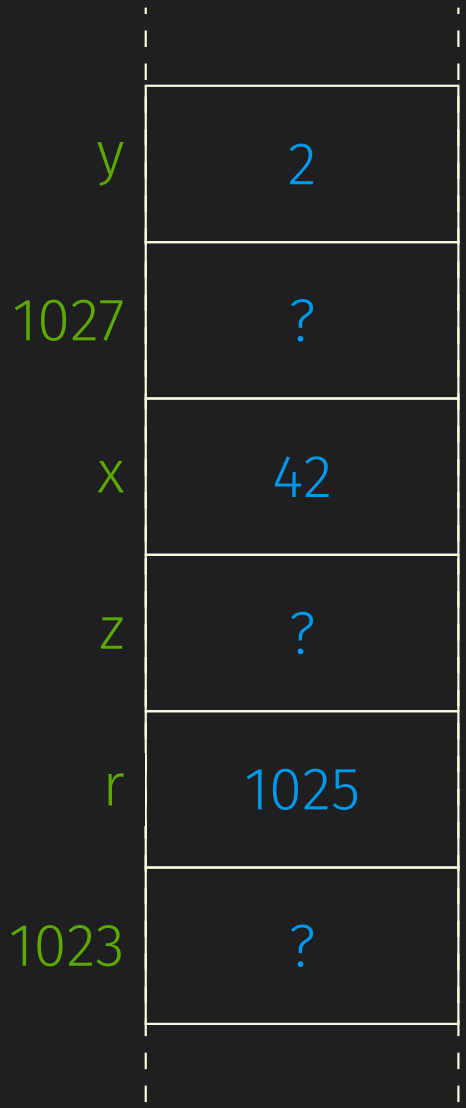
- The contents of the box whose address is stored in a pointer can be reached with the * operator:

```
1  *p = x * y;
```

References (C++ only)



- A **reference** is a special variable that refers to another variable. This is just a short-hand notation.

```
1  int x = 42; int y = 2; int z;
2  int &r = z;
```

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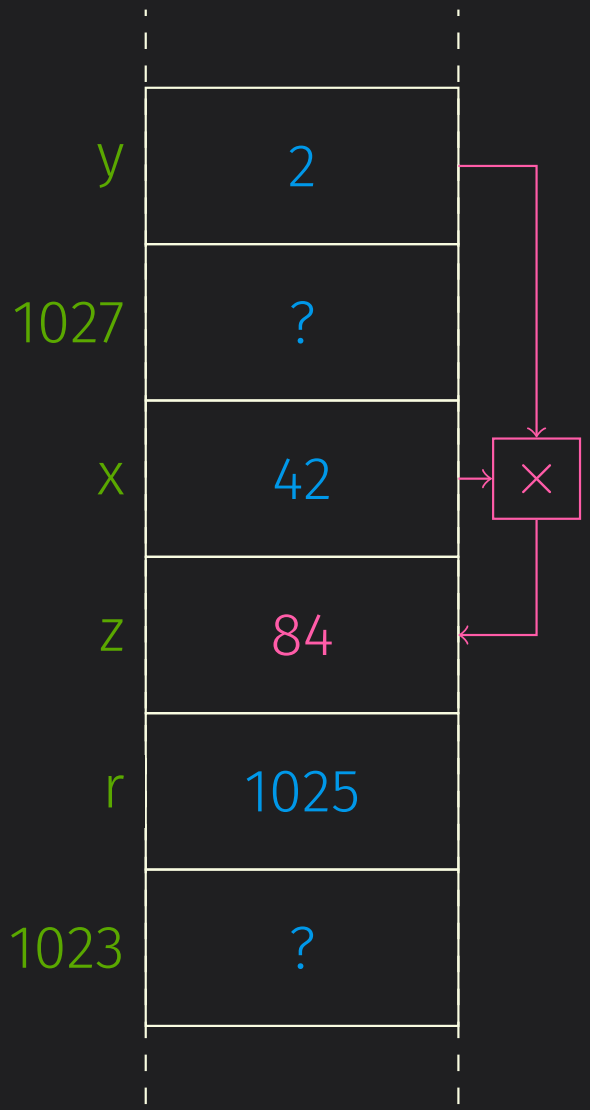

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```
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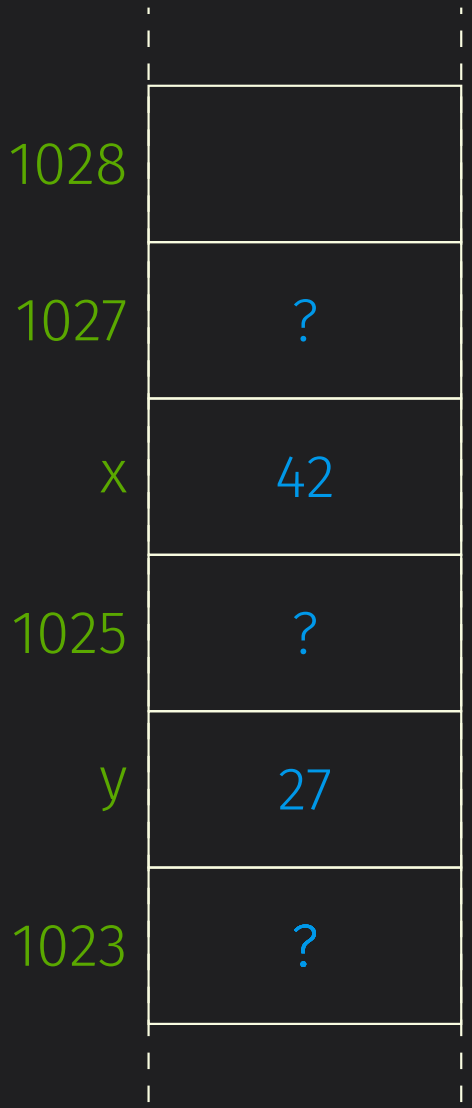
- References lets us use simpler syntax for the same effect:

```
1  r = x * y;
```

Pointers and Functions

Example: The swap Function



- We want to write a function **swap** that exchanges the values of two variables:

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1  int main(int argc, char *argv[]) {
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4  }
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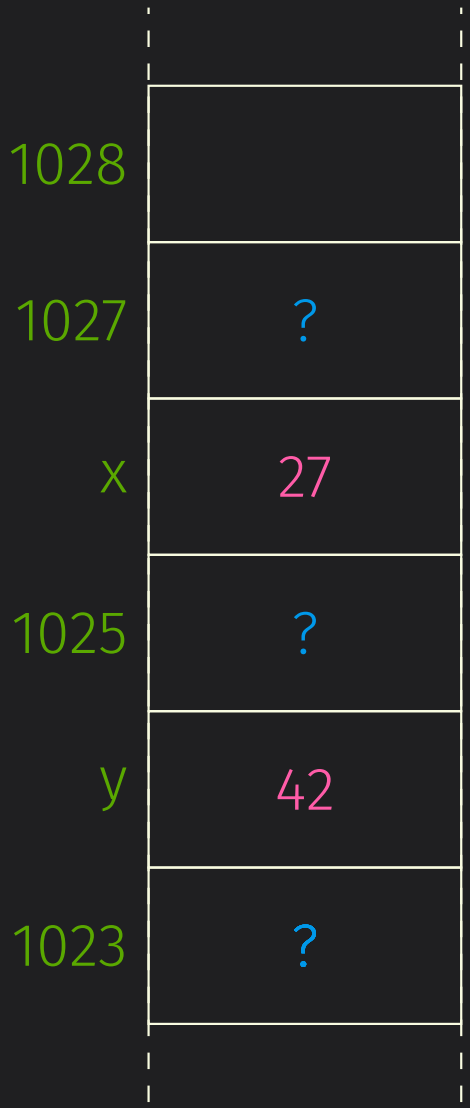

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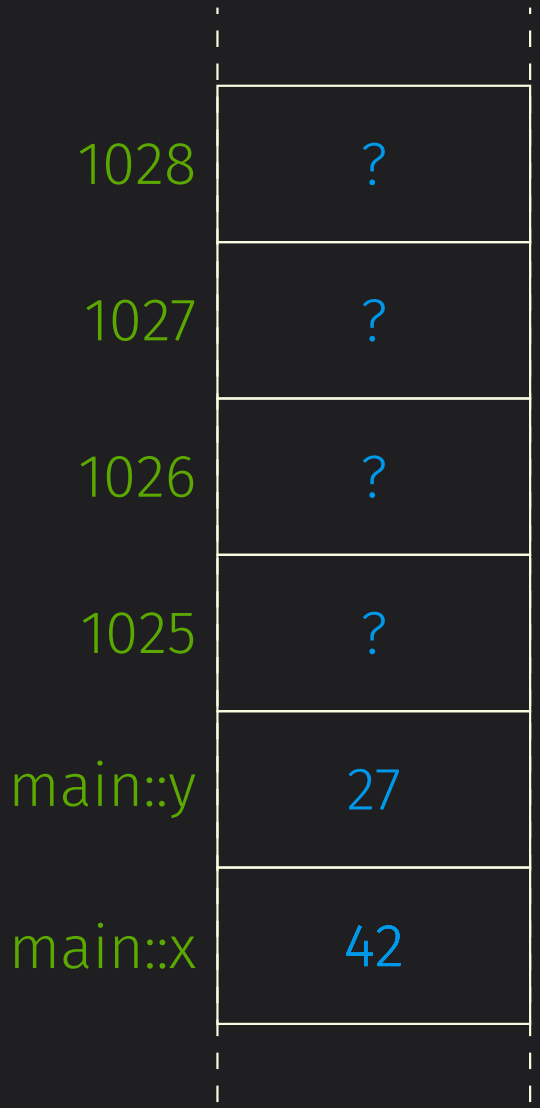
- After the **swap** call the variables should have the previous values of each other.

```
1  swap(x, y);
```

Example: swap, A First Try



- The following DOES NOT work since x and y inside the function are local variables:

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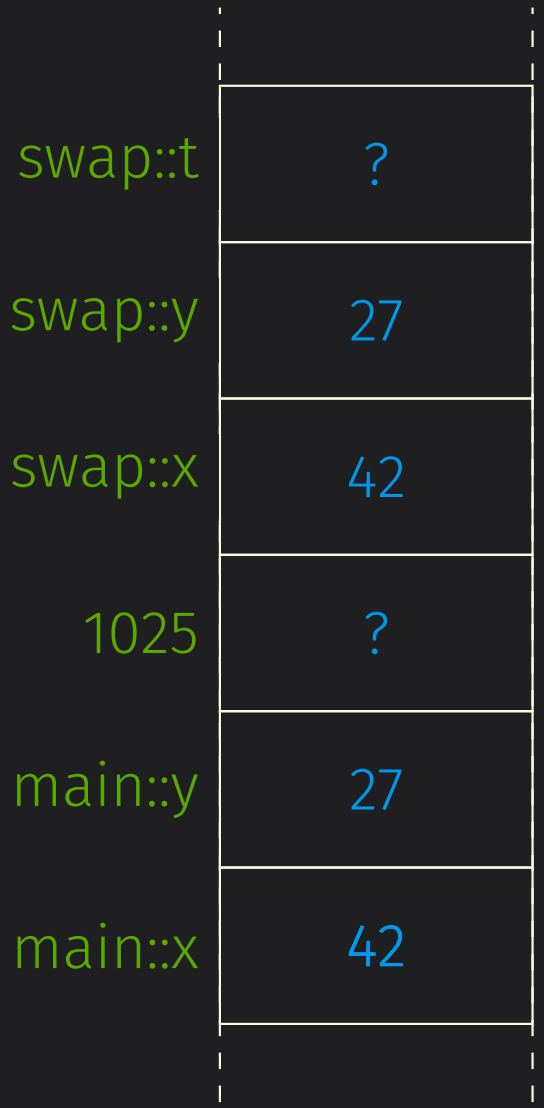

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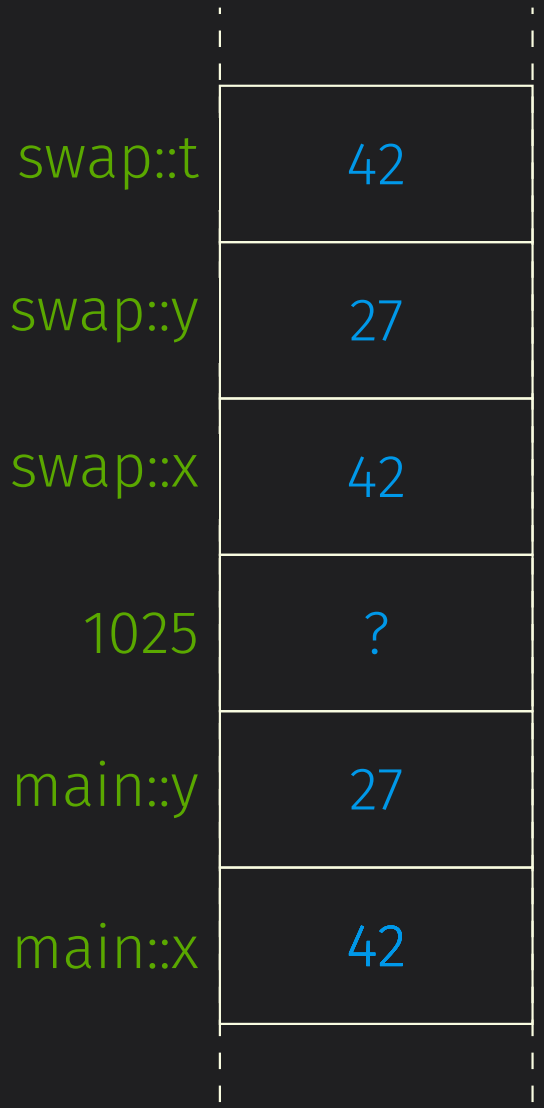

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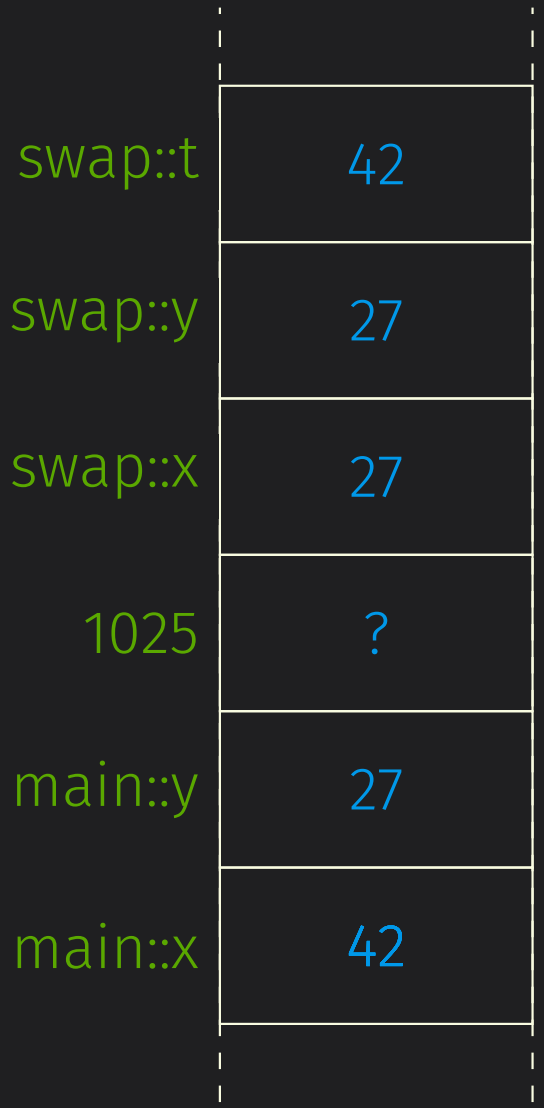

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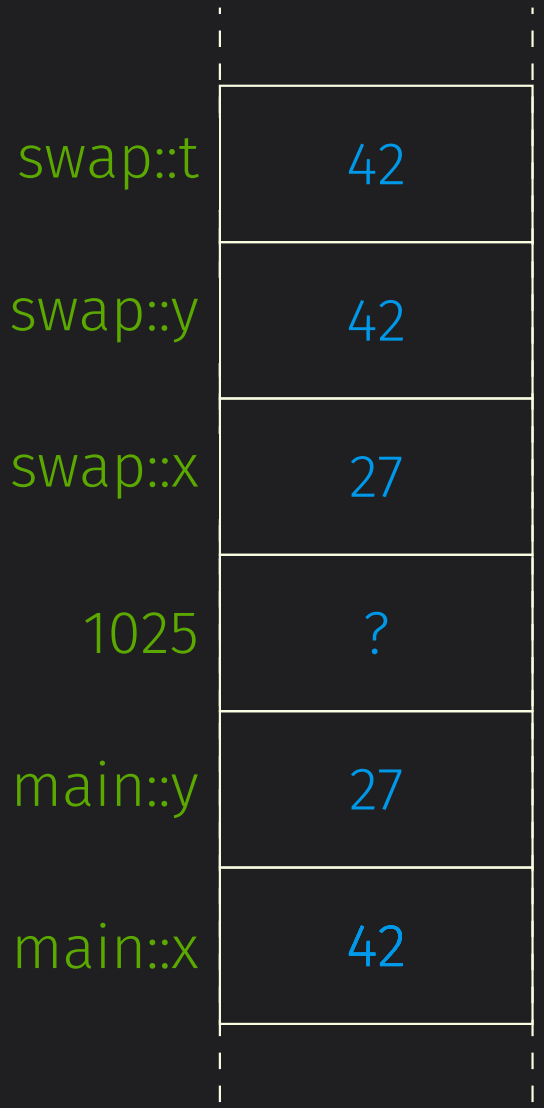

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- We need to call this version of swap with addresses of the variables:

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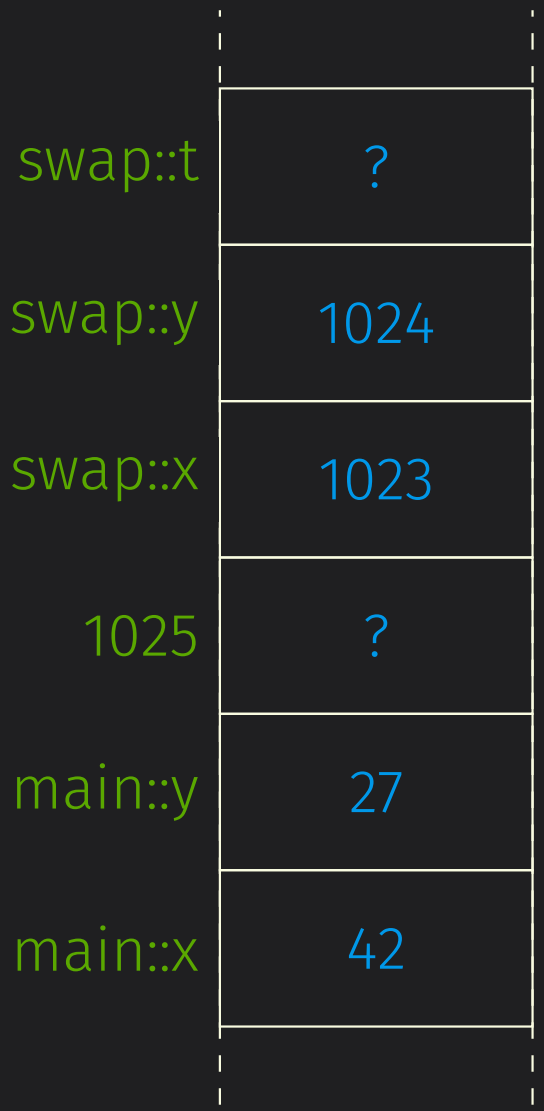

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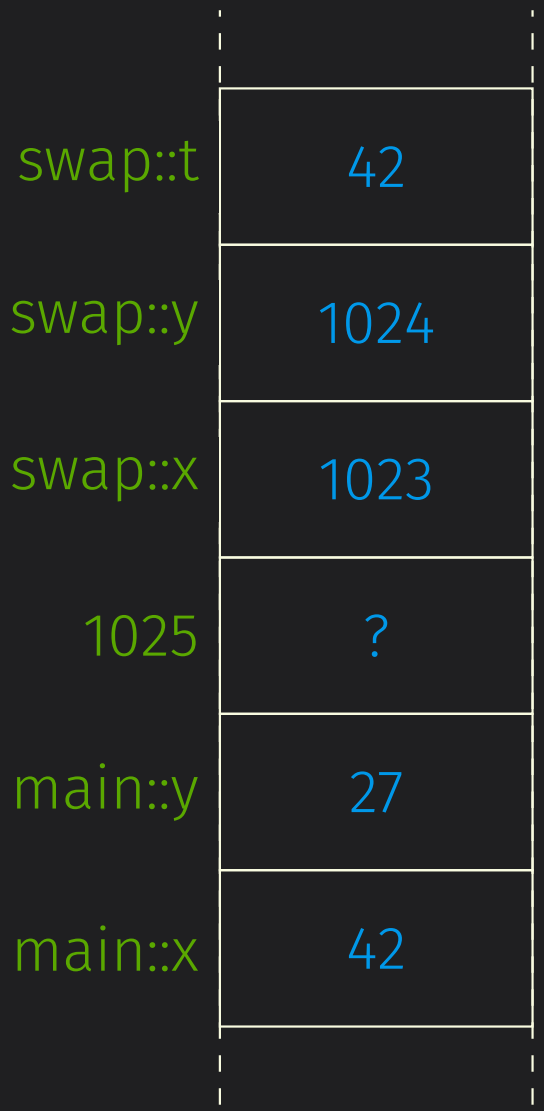

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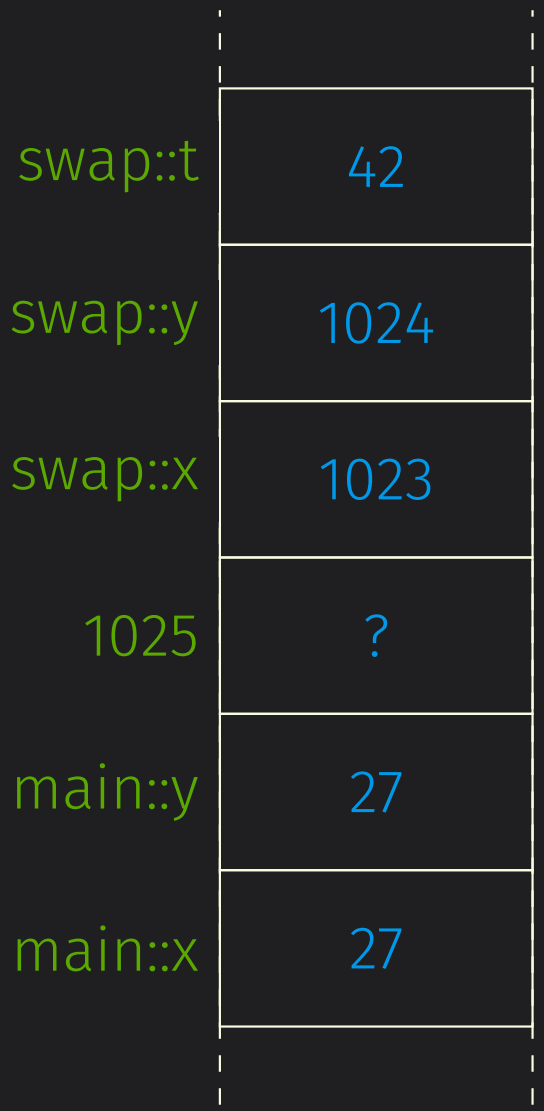

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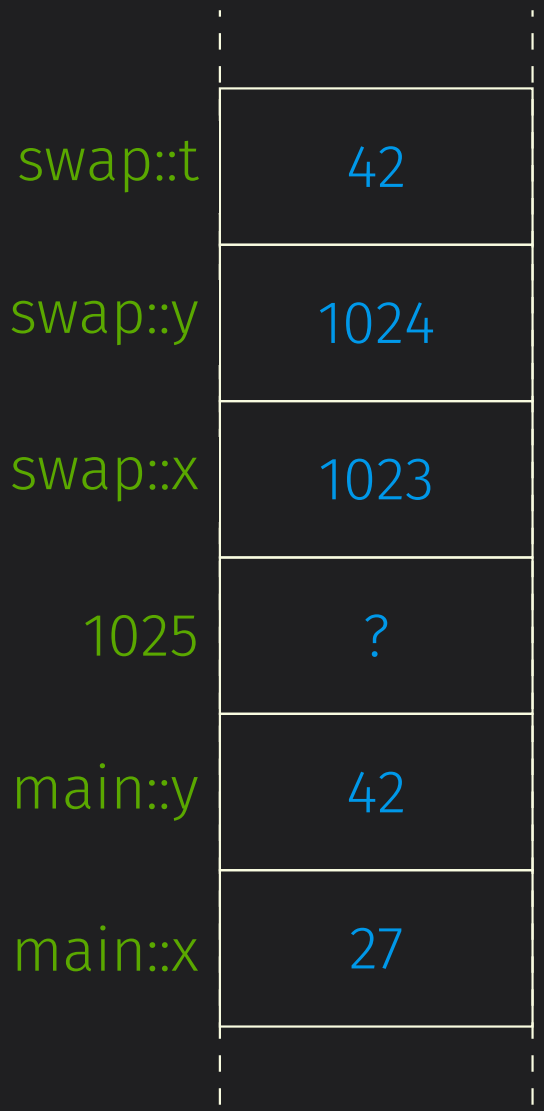

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5  }
6
7  int main(int argc, char *argv[]) {
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11 }
```
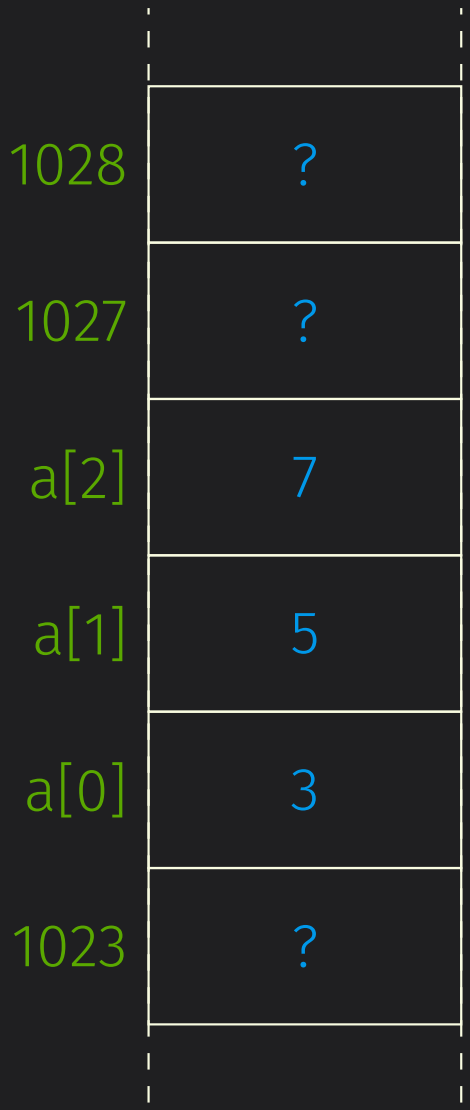

Arrays and Pointers

Fixed Size Arrays

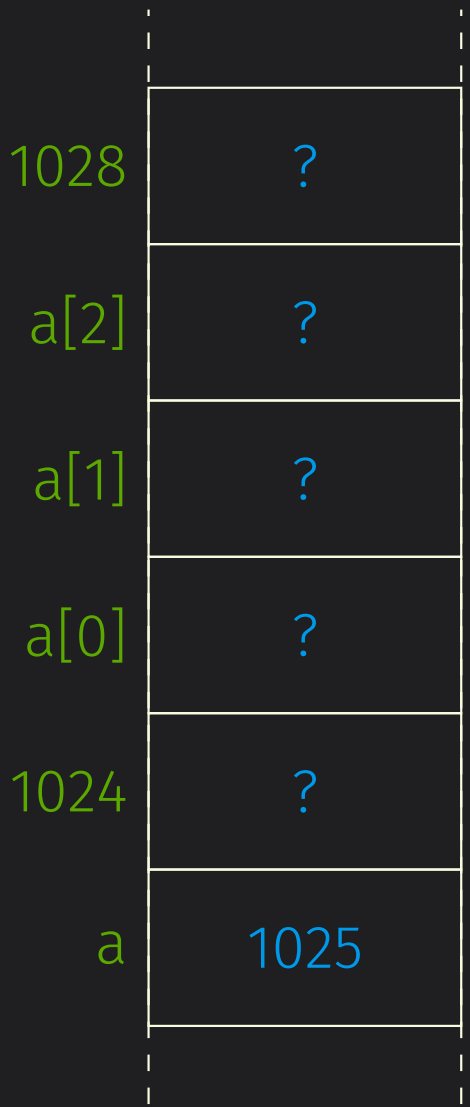


- When you need to store several items of the same type, you can declare an array variable:

```
1  int a[3] = {3,5,7};
```

- The size of the array needs to be a constant.
- The valid indices range from zero to size minus one.
- Accessing an item with a negative index or an index above or equal to size may lead to a crash of your program or it might just corrupt your data.

Dynamically Allocated Arrays



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```
1   int *a = new int[3];
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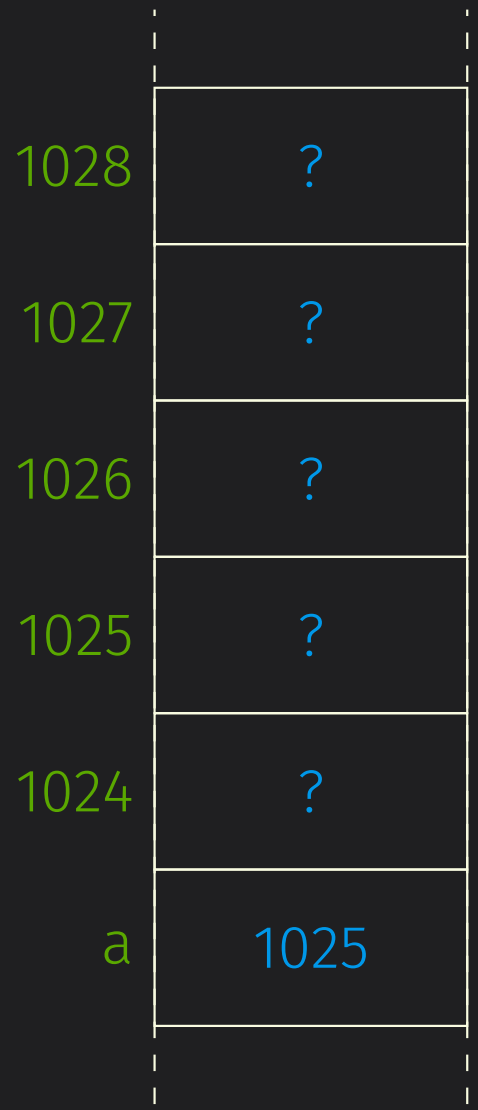

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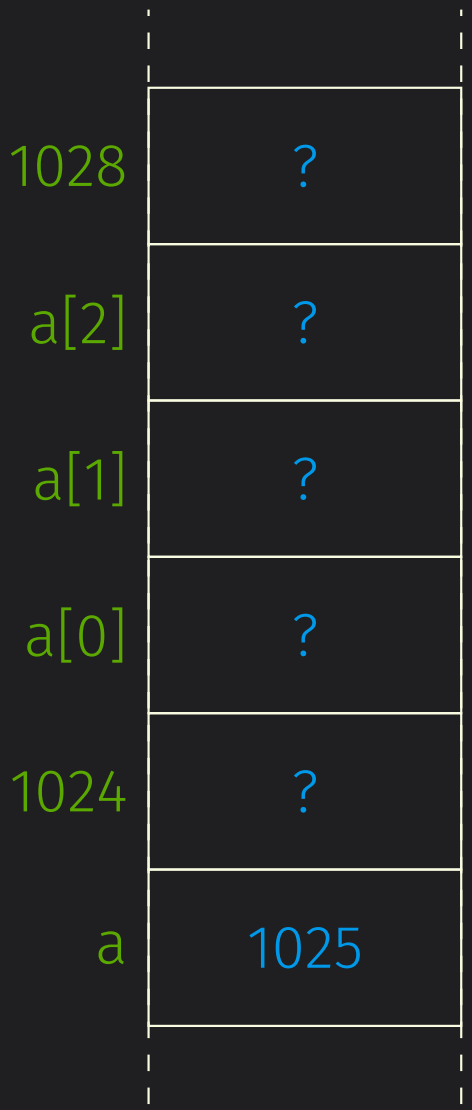
```
1   int *a = new int[3];
```

- Once you do not need the array, you need to deallocate the memory or a memory leak will occur:

```
1   delete [] a;
```

Deallocation of Arrays



- It is an error to read/write to the array after deallocation.
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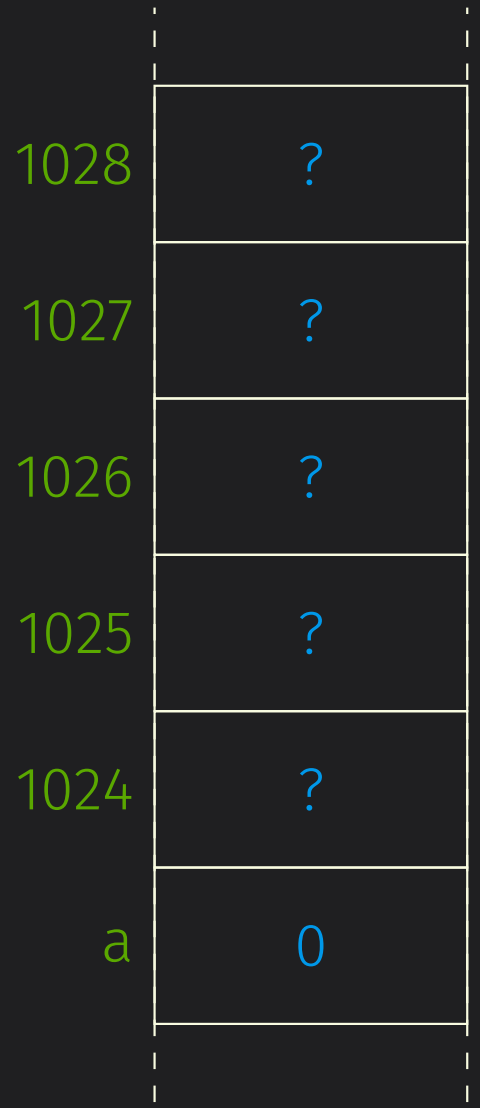

- It is an error to read/write to the array after deallocation.
- It is also an error to deallocate the same memory more than once.
- When you deallocate the memory, it is a good idea to the pointer to zero, which is called a null pointer.

```
1  int *a = new int[3];
2  delete [] a;
3  a = 0;
```

`std::vector` (C++ only)

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- Since working with C like arrays is difficult and manual memory management is error-prone, we will instead use the **`std::vector`** data structure from STL.
- Vectors are resizable arrays of a single data type. To use them you need to include the **`<vector>`** header file.
- The elements of the vector can be of any C++ data type and you need to fix it during variable declaration:

```
1  // An empty vector of integers.
2  vector<int> vi;
3  // A vector of floats initially containing 10 items.
4  vector<float> vf(10);
```

Vector Example

```
 9 vector<int> v(2);
10 cout << "Initial number of elements is " << v.size() << endl;
11
12 for (int i = 0; i < 5; ++i)
13         v.push_back(i);
14 cout << "Size after insertions is " << v.size() << endl;
15
16 cout << "Elements are ";
17 for (size_t i = 0; i < v.size(); ++i)
18         cout << v[i] << " ";
19 cout << endl;
```

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18         cout << v[i] << " ";
19 cout << endl;
```
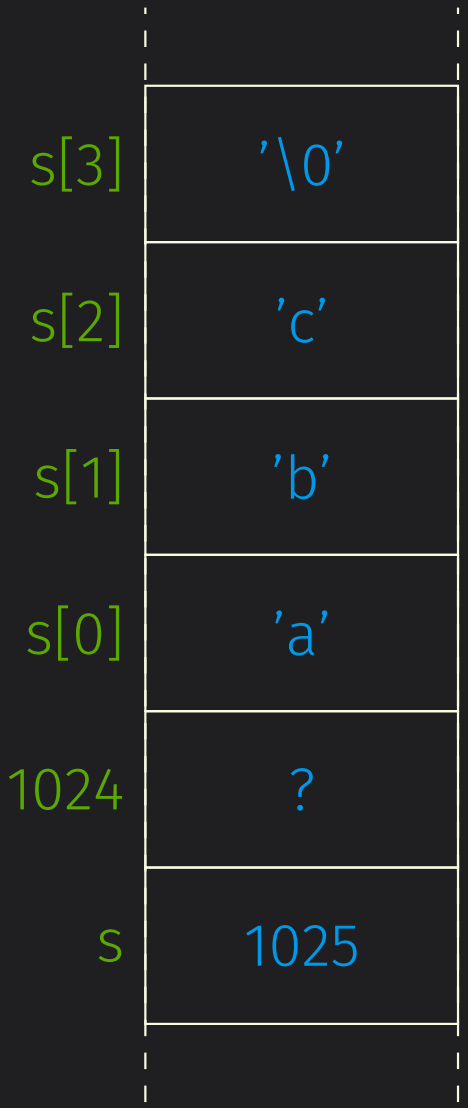

```
$ ./vectors
Initial number of elements is 2
Size after insertions is 7
Elements are 0 0 0 1 2 3 4
```

Character Arrays (C Strings)

Null-Terminated Strings



- In C, the strings are simply arrays of characters with a null (zero) chracter at the end:

```
1  const char s[] = "abc";
```

- Equivalently, you can write:

```
1  const char *s = "abc";
```

- You can use the **`strlen`** function to get the length of a string.

```
1  strlen("abc") == 3 -> true
```

C String Example

```
 9 const char *s1 = "Hello ";
10 const char *s2 = "World!";
11
12 char *s = new char[strlen(s1)+strlen(s2)+1];
13 strcpy(s, s1);
14 strcat(s, s2);
15 cout << s << endl;
16 delete [] s;
```

```
$ ./cstrings
Hello World!
```

std::string (C++ Only)

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- C++ string objects internally store a C string but they manage the memory themselves.
- You can get the size of a C++ string object by calling its `size()` method:

```
1  string s = "abc";
2  // This prints 3
3  cout << s.size() << endl;
```

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- Since working with C strings is difficult and manual memory management is error-prone, we will instead use **`std::string`** defined in the header **`<string>`**.
- C++ string objects internally store a C string but they manage the memory themselves.
- You can get the size of a C++ string object by calling its `size()` method:

```
1  string s = "abc";
2  // This prints 3
3  cout << s.size() << endl;
```

- You can concatanate C++ strings with the `+` operator:

```
1  string s = "Hello ";
2  s += "World!";
```