CSE 303
Concepts and Tools for Software Development

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Winter 2007
Lecture 7 – Introduction to C

Welcome to C

- Going from Java to C is like going from an automatic transmission to a stick shift
  - Lower level: much more is left for you to do
  - Unsafe: you can set your computer on fire
  - C standard library is much smaller
  - Similar syntax can both help and confuse
  - Not object oriented: paradigm shift

- We will also learn C++ later this quarter
  - Both better and worse than C

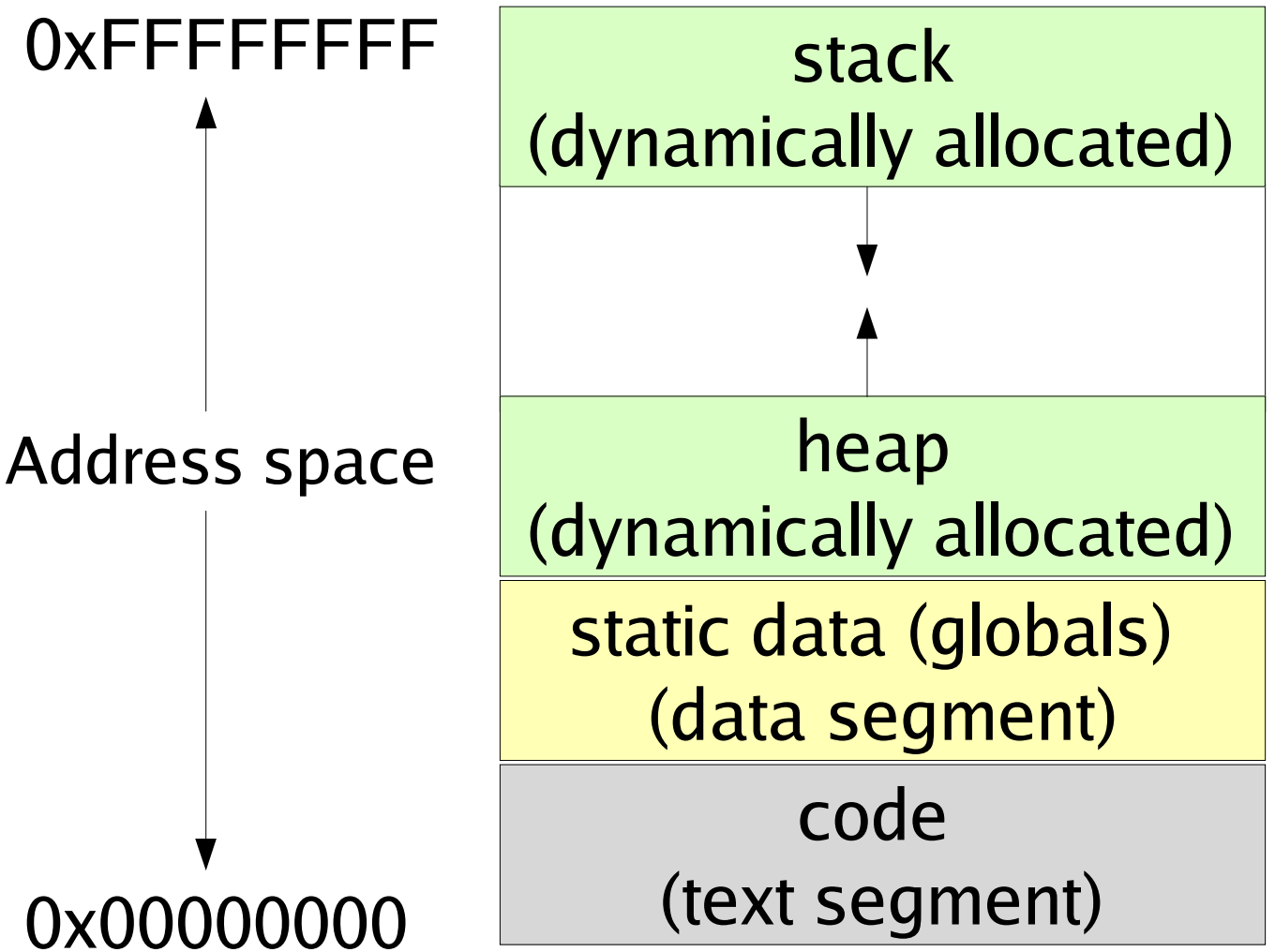
Our Plan for Learning C

- Learn non-object oriented programming
- Gain a deep understanding of
  - Memory management
  - Pointers
  - Program execution
  - We will “look under the covers”
- Acquire good debugging skills
- Acquire software development techniques
- And also learn the C syntax

Our Plan for Today

- Introduction to memory management
- Simple C programs
- A first look at pointers

Address Space of a Unix Process



Address space is just array of 8-bit bytes

Typical total size is: 2^{32}

We will assume that integer is 4 bytes

A *pointer* is just an index into this array

More about the Address Space

- An address refers to a position in this array
- Trying to read an unused part of the array may cause a "segmentation fault" (crash)
- Code: instructions of program (read-only)
- Static data contains global variables
- Stack: local variables and code address
  - Grows and shrinks as program executes
- Heap: data (Objects returned by Java's new)
  - Must manage manually

Hello World

```
#include <stdio.h>

/*
 * First C program
 */
int main() {

    printf("Hello World\n");

    return 0;

}
```

Testing Hello World

- To compile the program, `hello.c`

```
gcc -g -Wall -o hi hello.c
```

- To execute the program:

```
./hi
```

Compile Command Meaning

```
gcc -g -Wall -o hi hello.c
```

Meaning:

`gcc`: Gnu C Compiler

`-g`: include debugging information

`-Wall`: show all warnings

`-o hi`: specifies program name

If you do not specify a name

```
gcc -g -Wall hello.c
```

The executable will be called: `a.out`

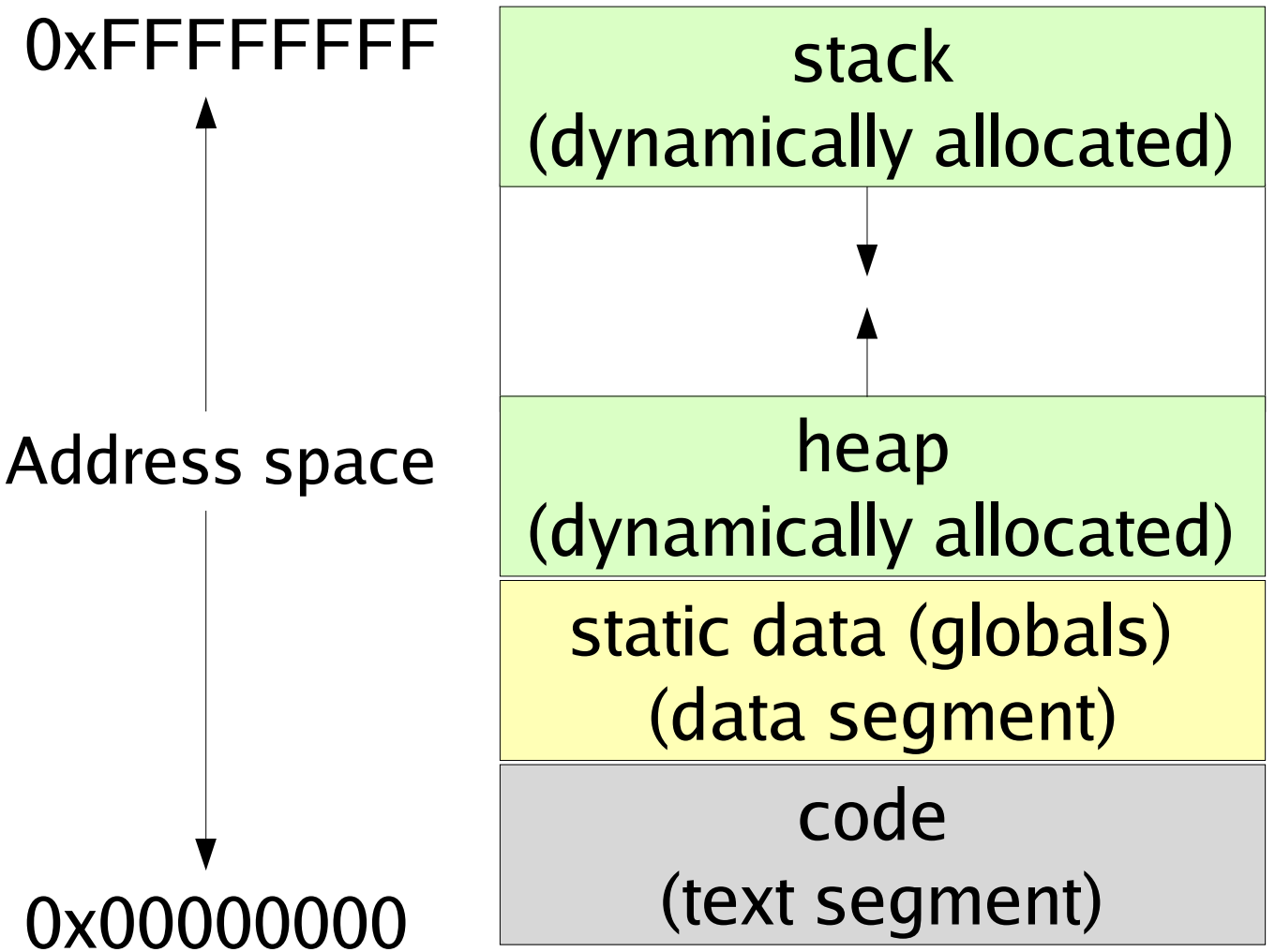
Quick Hello World Explanation

- `#include <stdio.h>`
  - Directive to the C preprocessor (more later)
  - Finds file `stdio.h`, includes its entire content
  - `stdio.h` is a header file
  - `stdio.h` describes `printf`
- `main` is a function
  - Every C program begins executing at the function `main`
- `\n` is an escape sequence. Means newline.

C Functions

- A lot like Java methods but...
  - They are not part of a class
  - They are not associated with an object
  - No “this”

Address Space of a Unix Process



Address space is just array of 8-bit bytes

Typical total size is: 2^{32}

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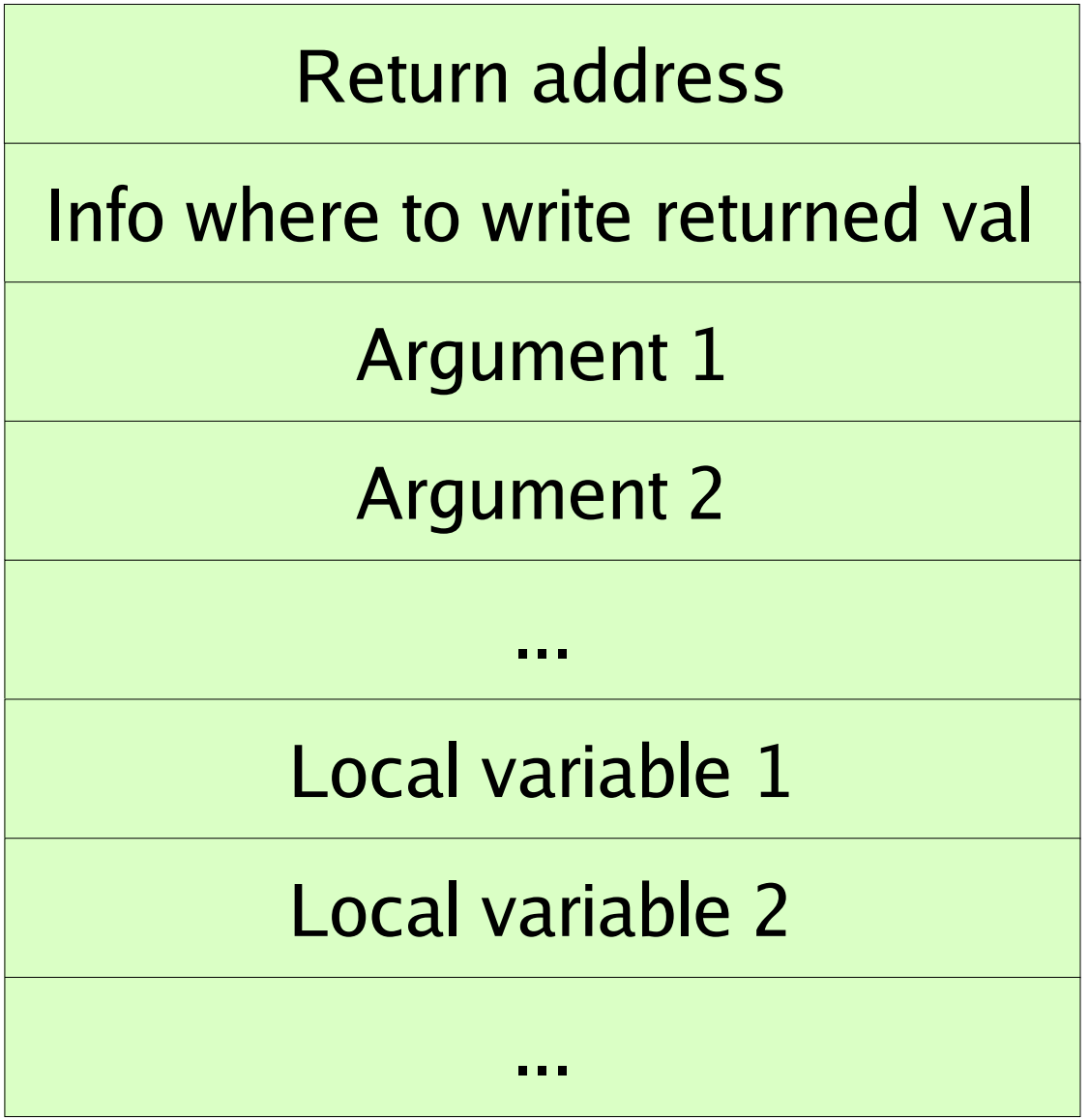
A *pointer* is just an index into this array

About the Stack

- The call-stack (or just stack) has one “part” or “frame” (also called activation record) for each function call that has not yet returned.
- It holds
  - Room for local variables
  - The return address (index into code for what to execute after the function is done)
- Hello World is not interesting to discuss the stack, so let's try a different example...

Activation Record



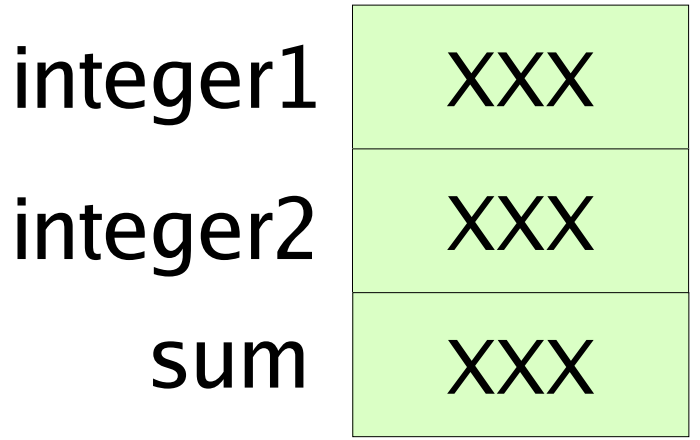
Note: each item on the stack can be many bytes in size

Local variables can appear in any order and may not be contiguous

Content of Stack

```
  #include <stdio.h>
1 int main() {
2     int integer1;
3     int integer2;
4     int sum;
5     integer1 = 10;
6     integer2 = 20;
7     sum = integer1 + integer2;
8     printf("\nSum is %d", sum);
9     return 0;
  }
```

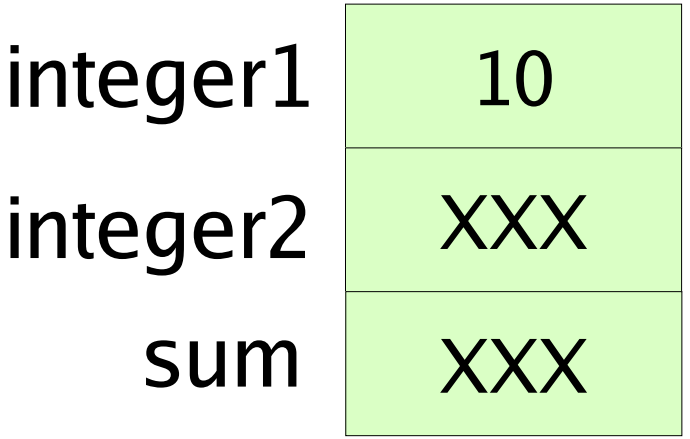
Stack after line 4



Content of Stack

```
  #include <stdio.h>
1 int main() {
2     int integer1;
3     int integer2;
4     int sum;
5     integer1 = 10;
6     integer2 = 20;
7     sum = integer1 + integer2;
8     printf(“\nSum is %d”, sum);
9     return 0;
  }
```

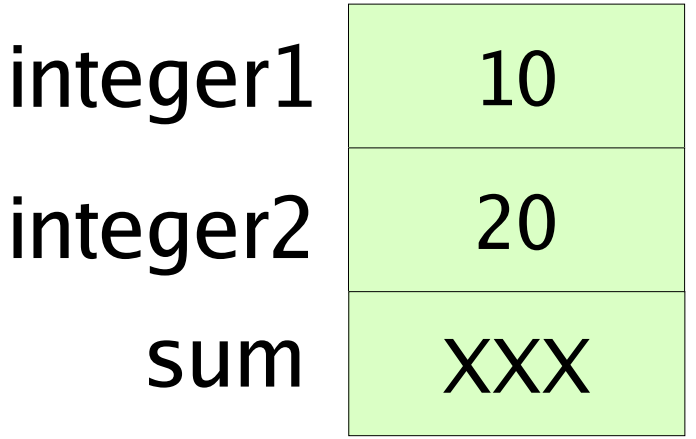
Stack after line 5



Content of Stack

```
  #include <stdio.h>
1 int main() {
2     int integer1;
3     int integer2;
4     int sum;
5     integer1 = 10;
6     integer2 = 20;
7     sum = integer1 + integer2;
8     printf("\nSum is %d", sum);
9     return 0;
  }
```

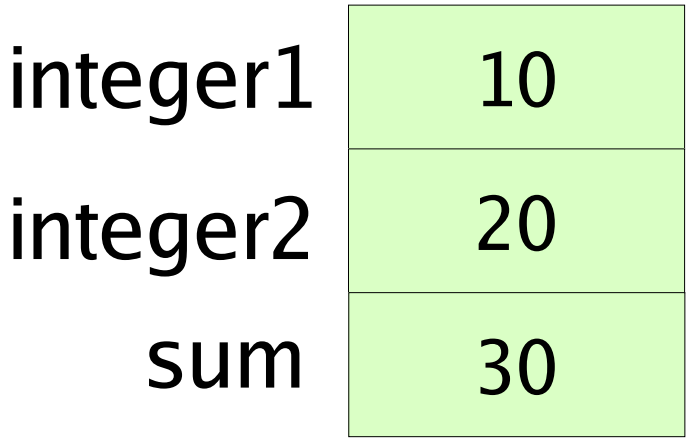
Stack after line 6



Content of Stack

```
  #include <stdio.h>
1 int main() {
2     int integer1;
3     int integer2;
4     int sum;
5     integer1 = 10;
6     integer2 = 20;
7     sum = integer1 + integer2;
8     printf("\nSum is %d", sum);
9     return 0;
  }
```

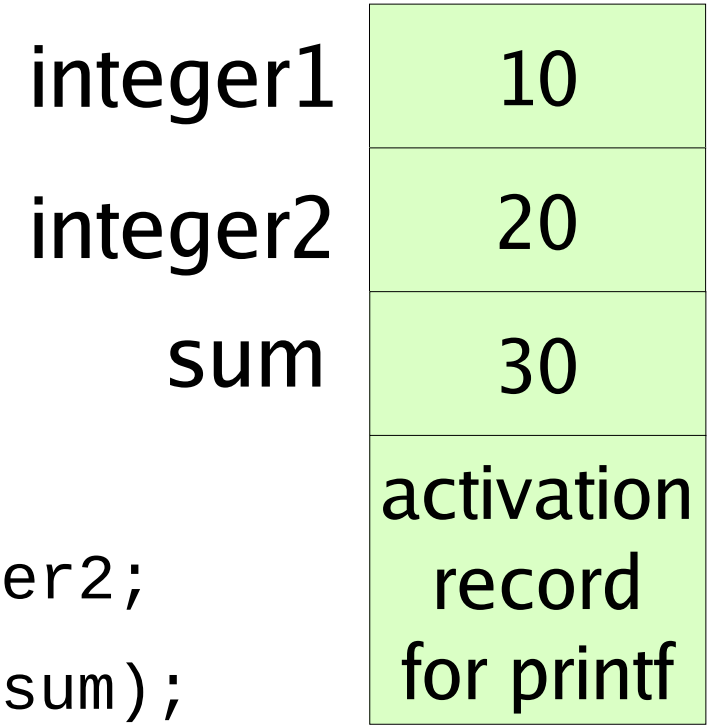
Stack after line 7



Content of Stack

```
  #include <stdio.h>
1 int main() {
2     int integer1;
3     int integer2;
4     int sum;
5     integer1 = 10;
6     integer2 = 20;
7     sum = integer1 + integer2;
8     printf("\nSum is %d", sum);
9     return 0;
  }
```

Stack during execution of printf



Introduction to Pointers

- Address of something is index into address-space array: `&integer1;`
- Declaring a pointer to an integer

```
int *mypointer;
```

- Assigning an address to a pointer

```
mypointer = &integer1;
```

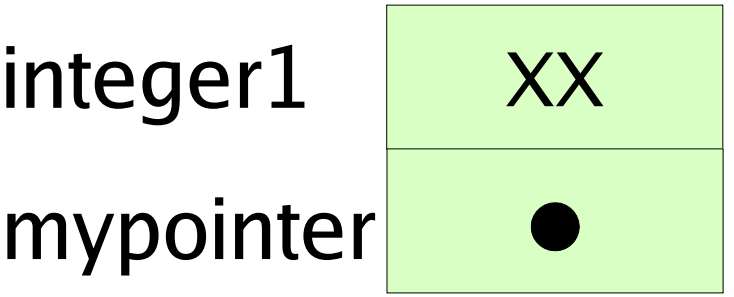
- Accessing data pointed to by pointer

```
*mypointer
```

Example with Pointers

```
  #include <stdio.h>
1 int main() {
2     int integer1;
3     int *mypointer;
4     integer1 = 10;
5     mypointer = &integer1;
6     printf("\nValue is %d", integer1);
7     printf("\nValue is %d", *mypointer);
8     return 0;
  }
```

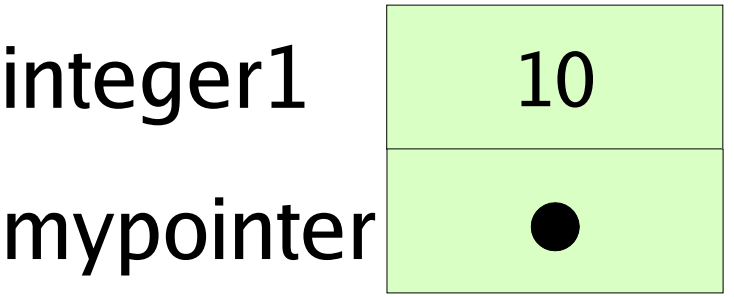
Stack after line 3



Example with Pointers

```
  #include <stdio.h>
1 int main() {
2     int integer1;
3     int *mypointer;
4     integer1 = 10;
5     mypointer = &integer1;
6     printf("\nValue is %d", integer1);
7     printf("\nValue is %d", *mypointer);
8     return 0;
  }
```

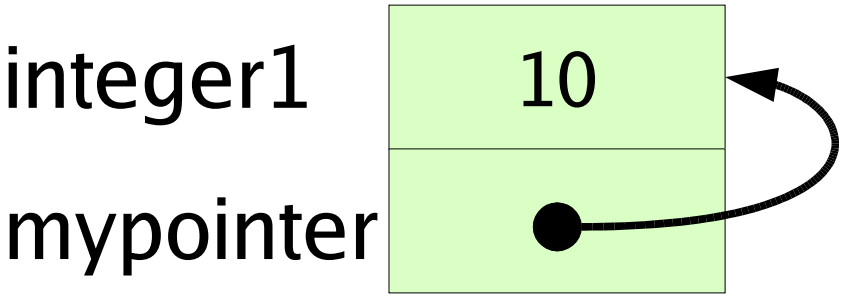
Stack after line 4



Example with Pointers

```
  #include <stdio.h>
1 int main() {
2     int integer1;
3     int *mypointer;
4     integer1 = 10;
5     mypointer = &integer1;
6     printf("\nValue is %d", integer1);
7     printf("\nValue is %d", *mypointer);
8     return 0;
  }
```

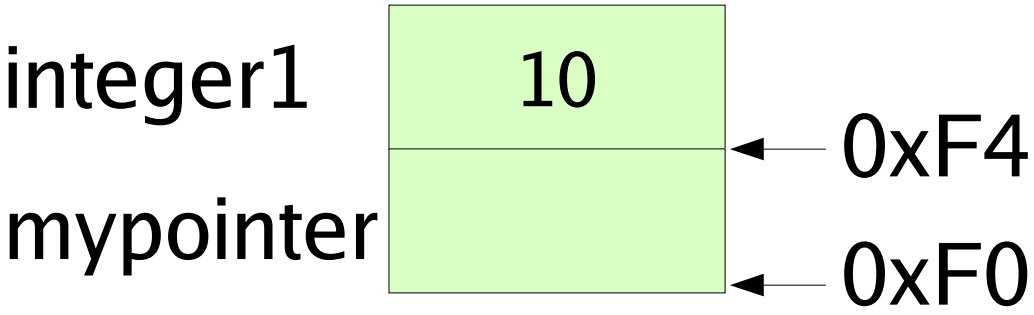
Stack after line 5



Example with Pointers

```
  #include <stdio.h>
1 int main() {
2     int integer1;
3     int *mypointer;
4     integer1 = 10;
5     mypointer = &integer1;
6     printf("\nValue is %d", integer1);
7     printf("\nValue is %d", *mypointer)
8     printf("\nAddress is %p", mypointer);
9     return 0;
  }
```

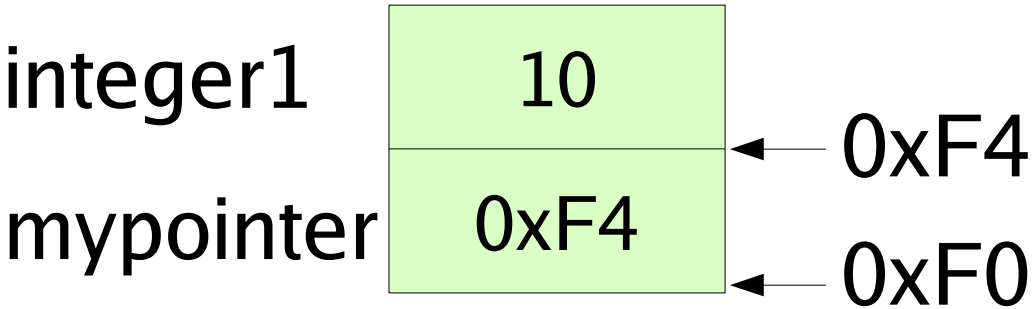
Stack after line 5



Example with Pointers

```
  #include <stdio.h>
1 int main() {
2     int integer1;
3     int *mypointer;
4     integer1 = 10;
5     mypointer = &integer1;
6     printf(“\nValue is %d”, integer1);
7     printf(“\nValue is %d”, *mypointer)
8     printf(“\nAddress is %p”, mypointer);
9     return 0;
  }
```

Stack after line 5



Readings

- Programming in C
  - Note: skim sections that look familiar to you! The book assumes NO programming background
  - Chapter 1: Introduction (you need to know that you may encounter **different versions of C**)
  - Chapter 2: Fundamentals
    - We will get back to compiling and linking later
  - Chapter 3: Compiling and Running
  - **Chapter 11: Pointers (only pages 235-240)**