CS107, Lecture 11 Extras
Stack and Heap

Reading: K&R 5.6-5.9 or Essential C section 6 on the heap
Ed Discussion: https://edstem.org/us/courses/46162/discussion/3644944

The Stack with Recursion

Each function **call** has its own *stack frame* for its own copy of variables.

```
int factorial(int n) {
    if (n == 1) {
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int main(int argc, char *argv[]) {
    printf("%d", factorial(4));
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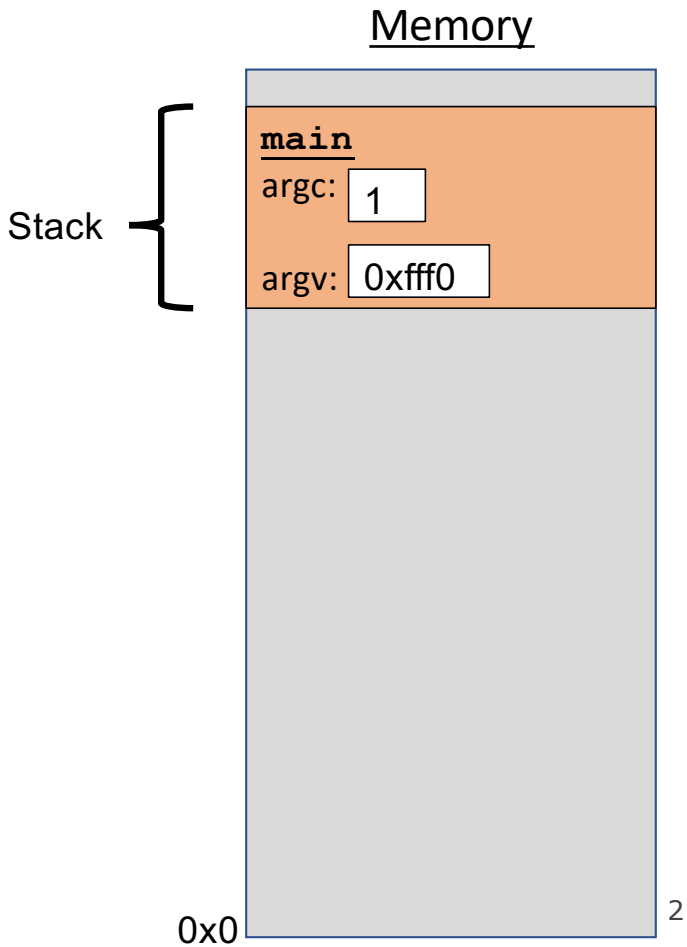

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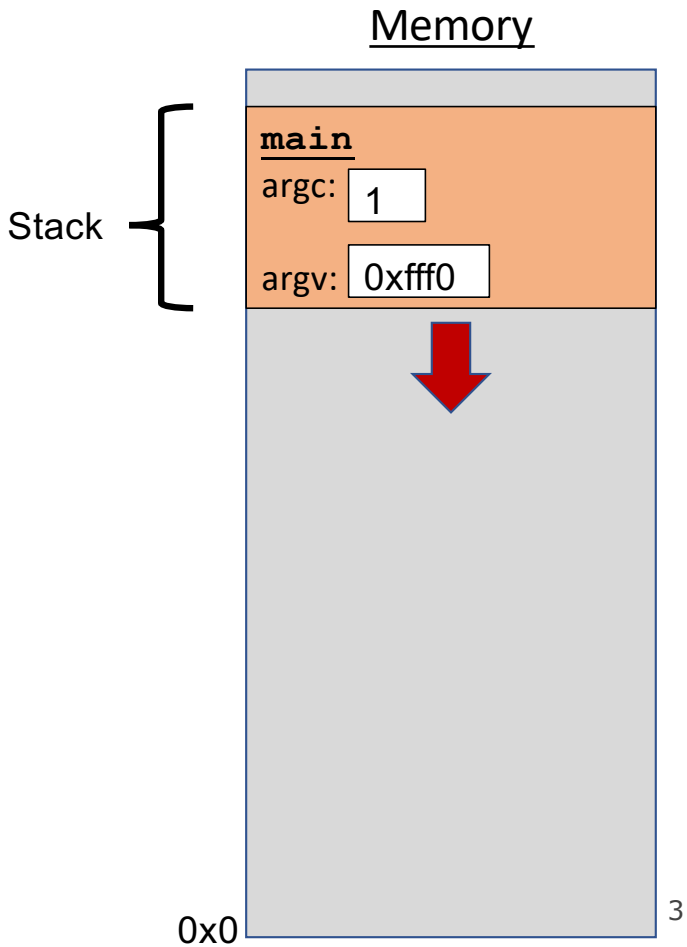

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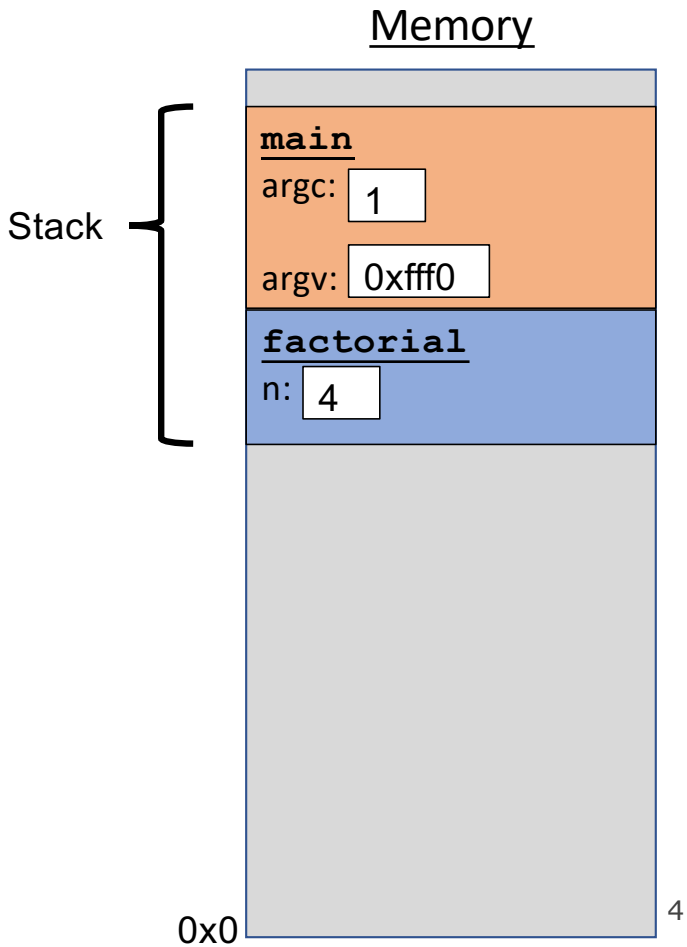

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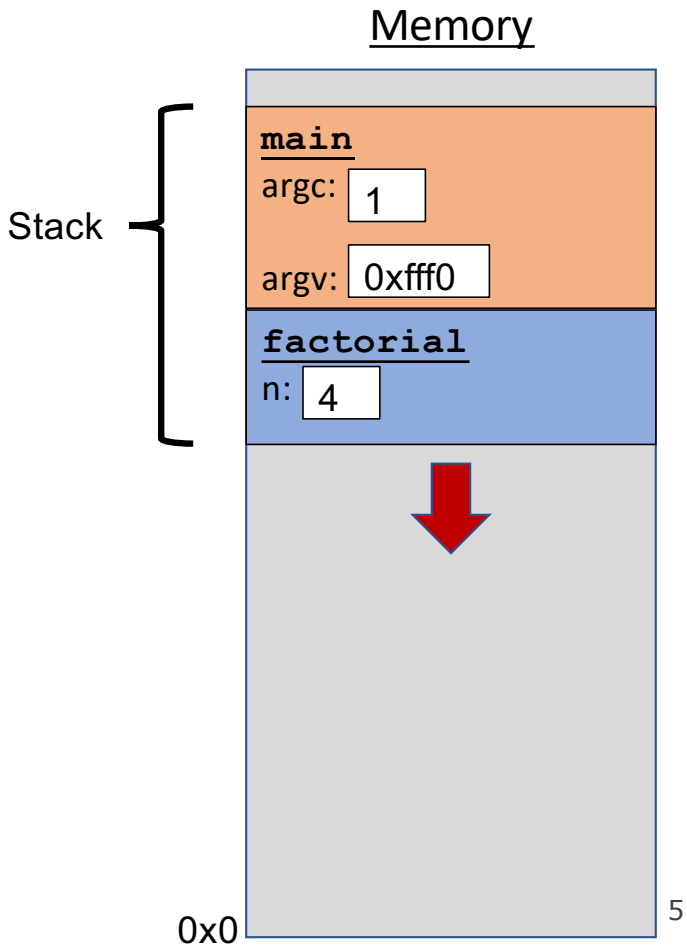

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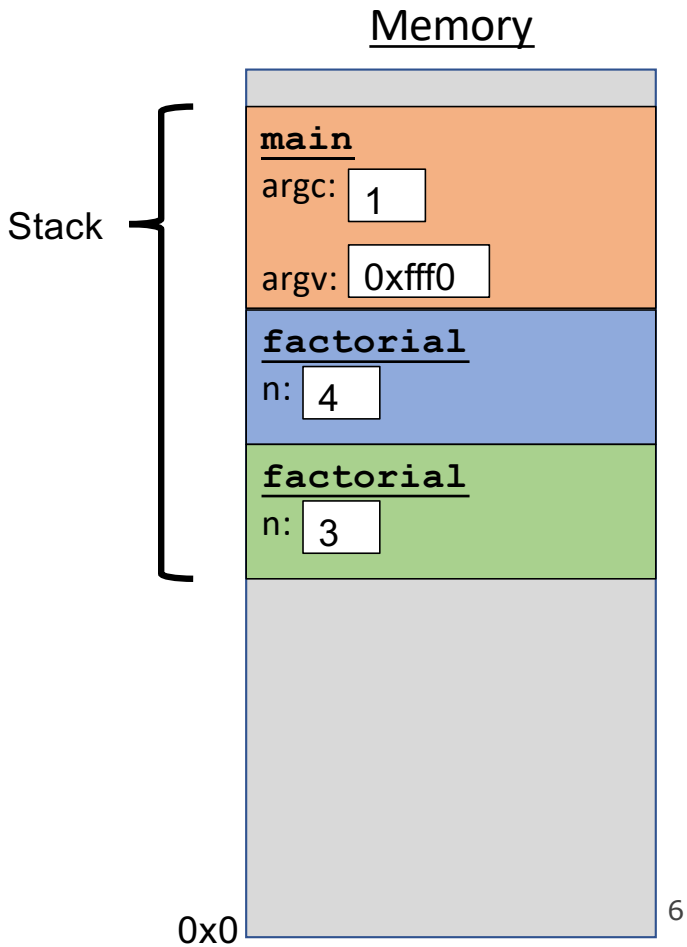

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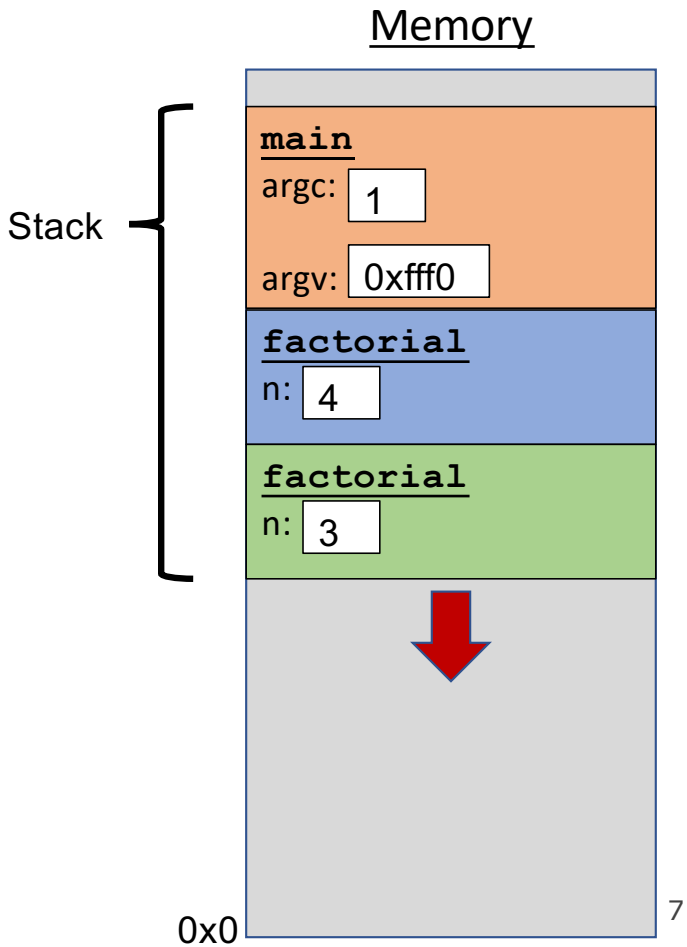

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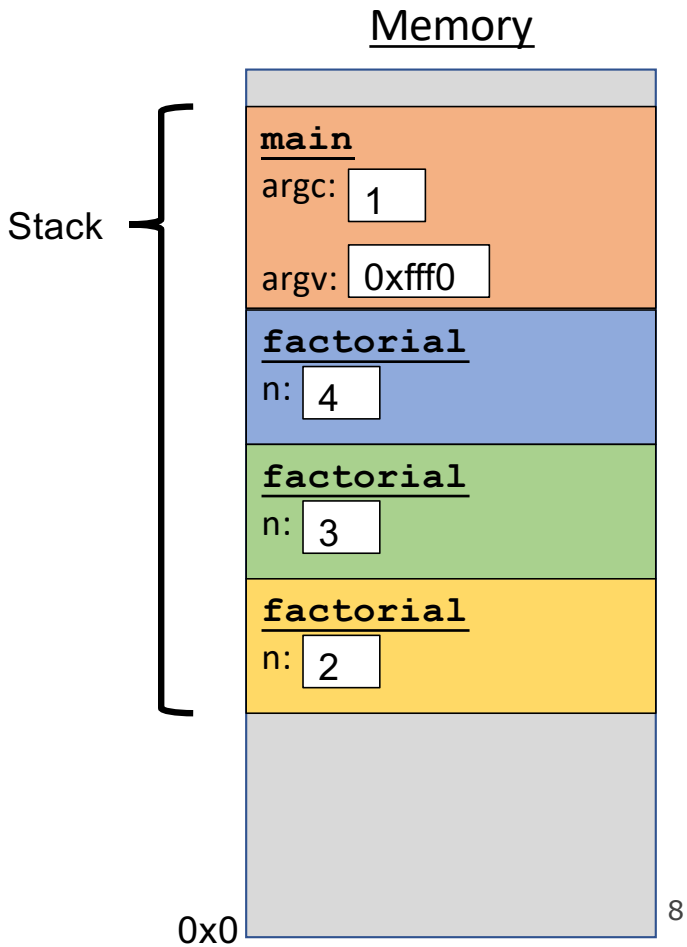

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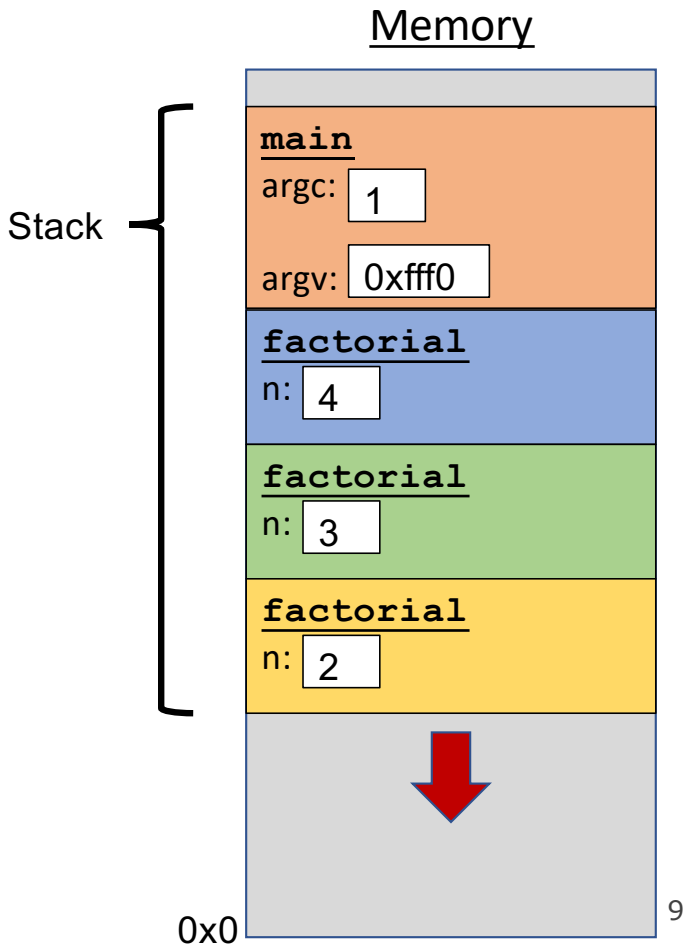

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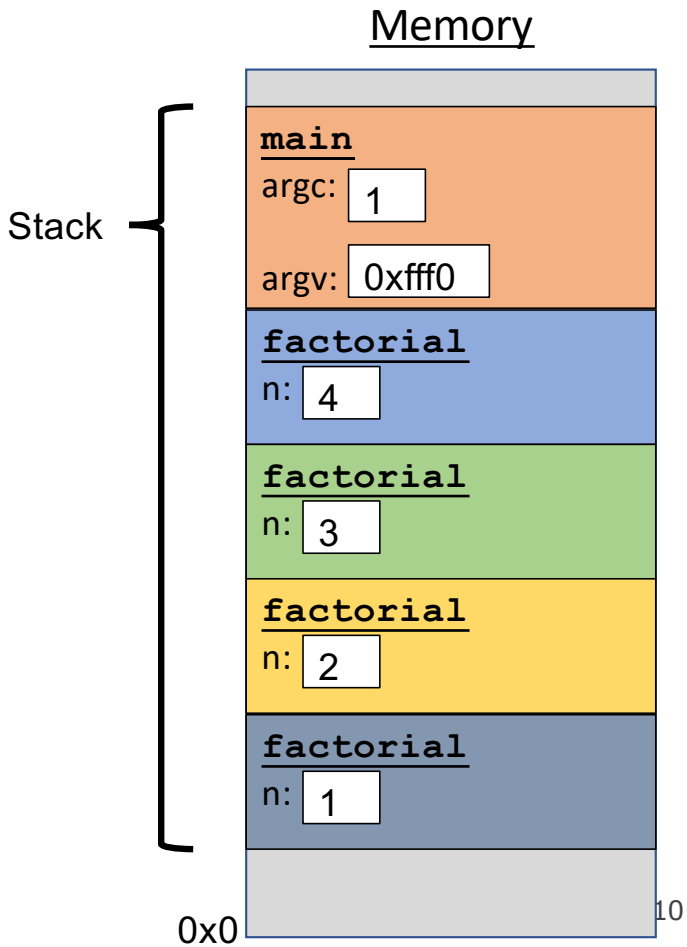

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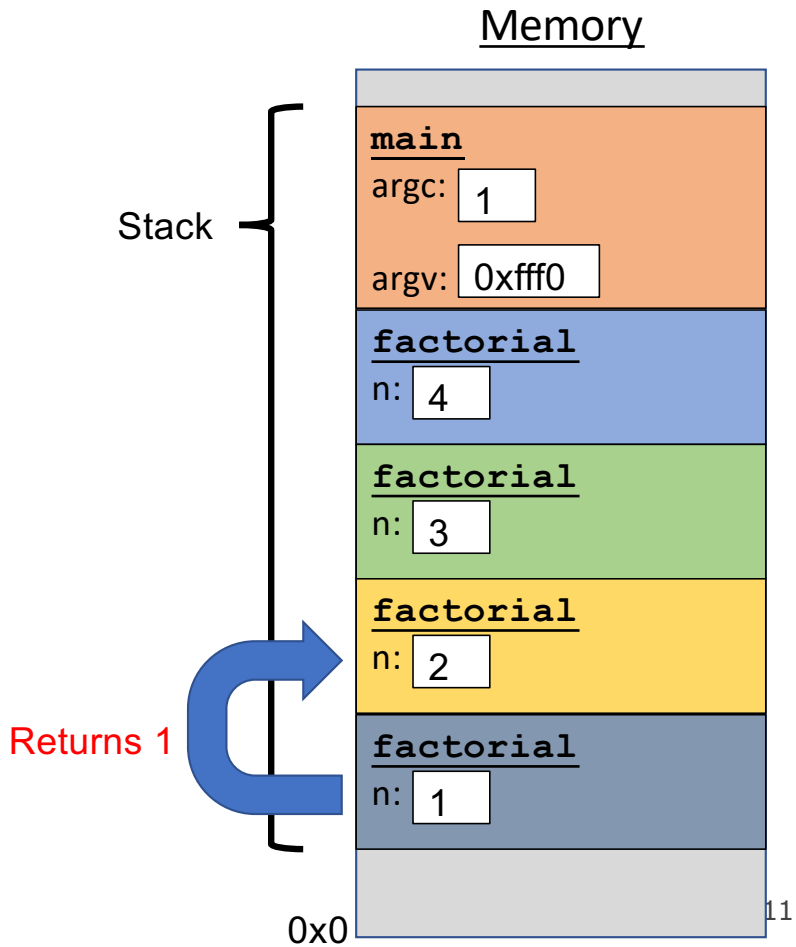

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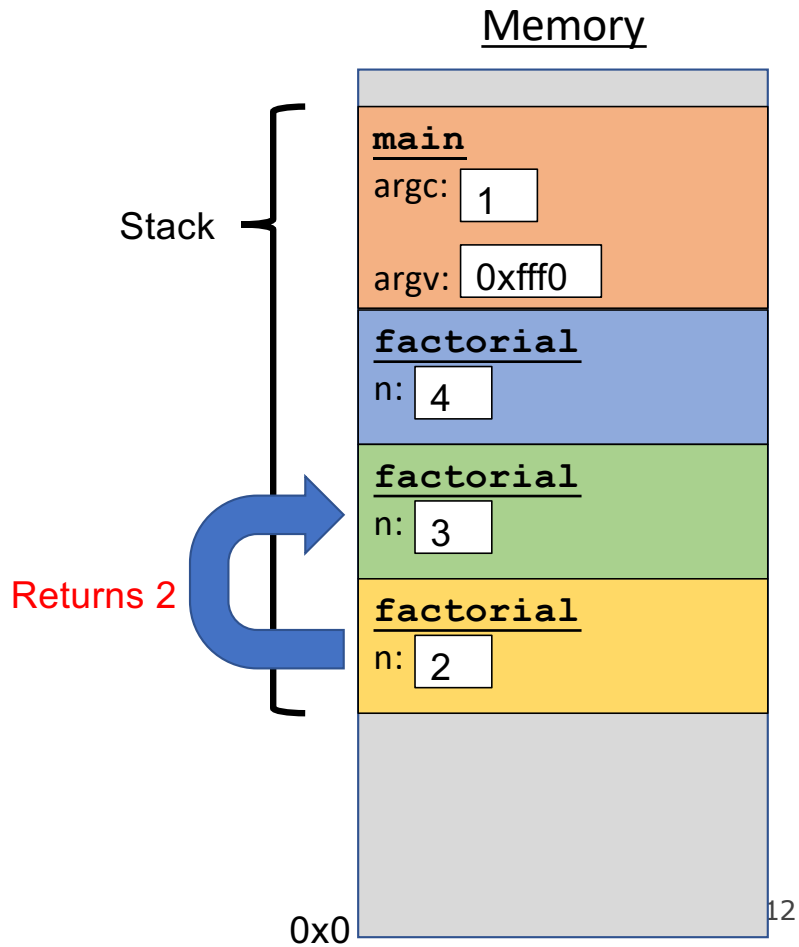

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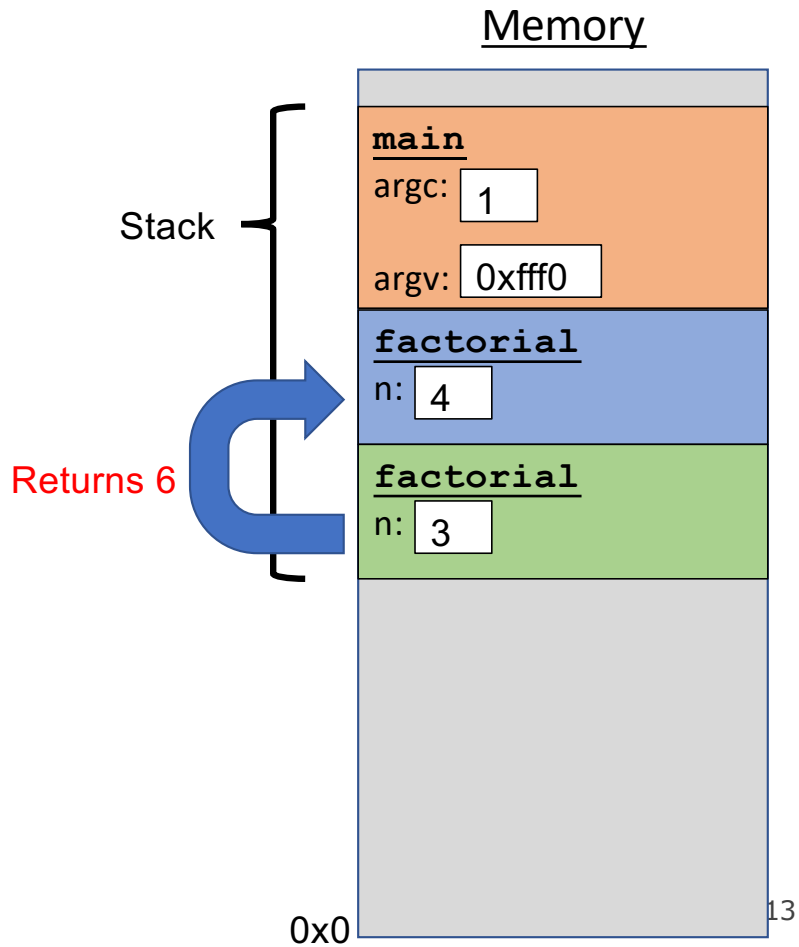

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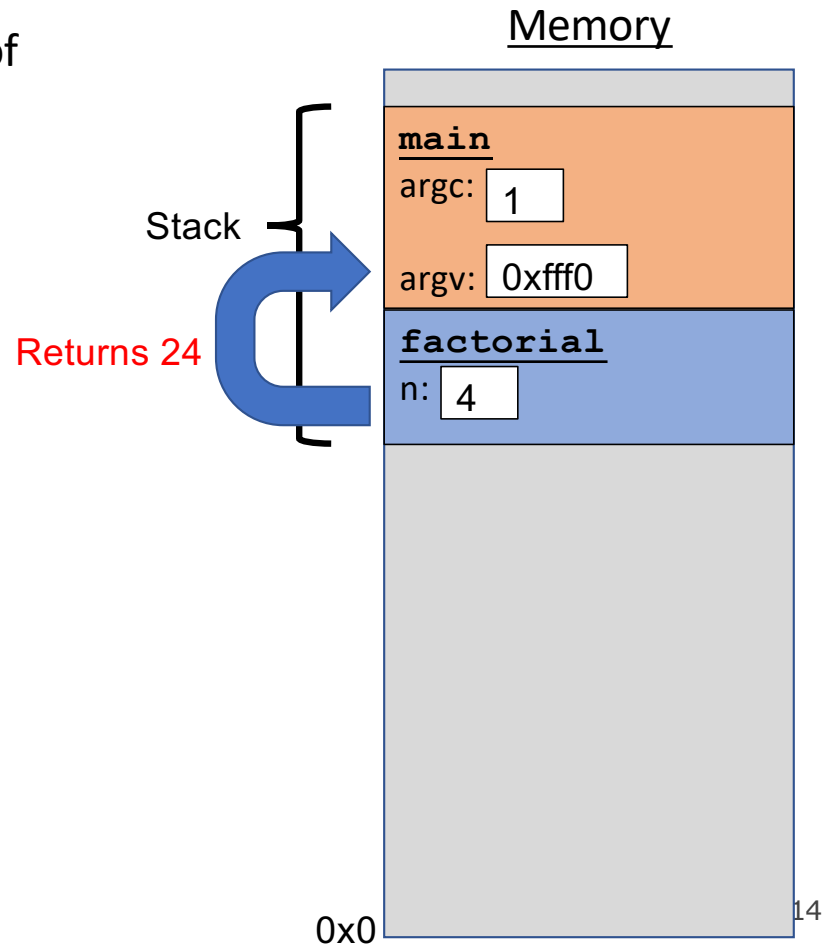

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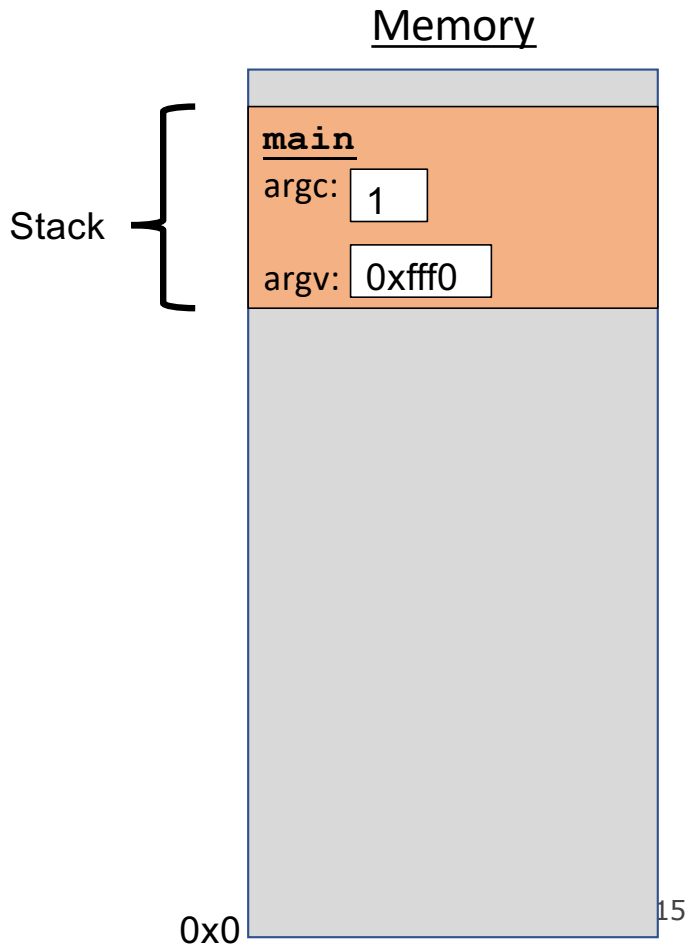

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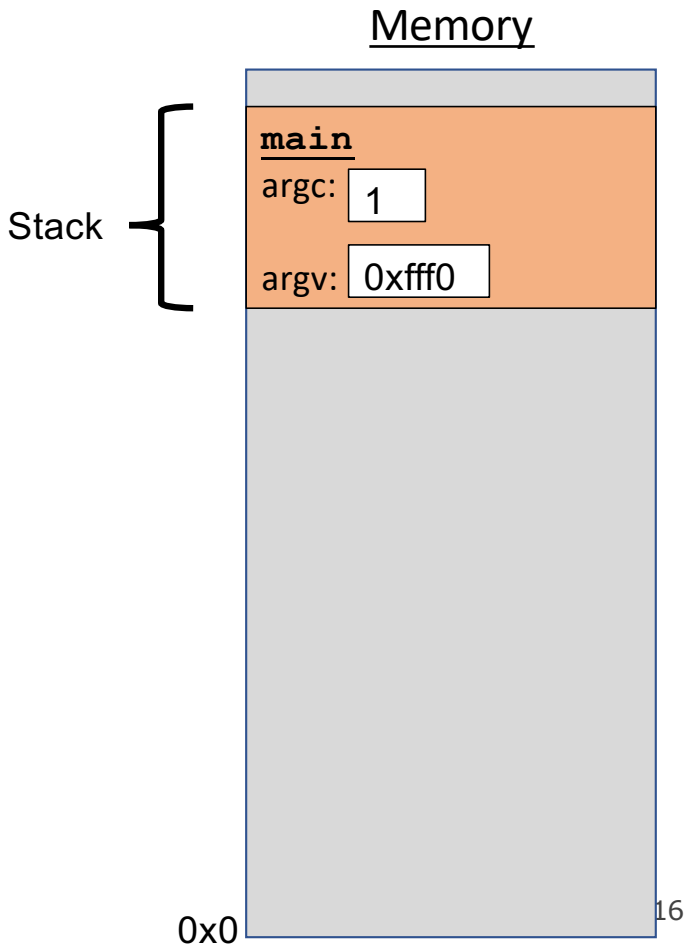

Extra Practice

`strdup` means string duplicate

How can we implement **strdup** using functions we've already seen?

```
1 char *mystrdup(const char *str) {
2     char *heapstr = _____(A)_____;
3     _____(B)_____;
4     _____(C)_____;
5     return heapstr;
6 }
```

[Note] Use library functions:
`<stdlib.h>`: `malloc`
`<assert.h>`: `assert`
`<string.h>`: `strcpy, strlen`

`strdup` means string duplicate

How can we implement **strdup** using functions we've already seen?

```
1 char *mystrdup(const char *str) {
2     char *heapstr = malloc(strlen(str) + 1);
3     assert(heapstr != NULL);
4     strcpy(heapstr, str);
5     return heapstr;
6 }
```

`char` arrays differ from other arrays in that valid strings must be null-terminated (i.e., have an extra ending `char`).

(Note: library strdup doesn't have an `assert`—it leaves the `assert` to the callee)

Goodbye, Free Memory

Where/how should we free memory below so that all memory is freed properly?

```
1 char *str = strdup("Hello");
2 assert(str != NULL);
3 char *ptr = str + 1;
4 for (int i = 0; i < 5; i++) {
5   int *num = malloc(sizeof(int));
6   *num = i;
7   printf("%s %d\n", ptr, *num);
8 }
9 printf("%s\n", str);
```

Recommendation: Don't worry about putting in frees until **after** you're finished with functionality.

Memory leaks will rarely crash your CS107 programs.

Answer in chat:

"After line N: free(…);"

What if we didn't free?

```
valgrind --leak-check=full --show-leak-kinds=all …
```

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4  for (int i = 0; i < 5; i++) {
5    int *num = malloc(sizeof(int));
6    *num = i;
7    printf("%s %d\n", ptr, *num);
8    free(num);
9  }
10 printf("%s\n", str);
11 free(str);
```

Recommendation: Don't worry about putting in frees until **after** you're finished with functionality.

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```
valgrind --leak-check=full --show-leak-kinds=all …
```

strcat_extend

Write a function that takes in a heap-allocated **str1,** enlarges it, and concatenates **str2** onto it.

```
1 char *strcat_extend(char *heap_str, const char *concat_str) {
2     (_____________________(1)_____________________);
3     heap_str = realloc(___(2A)___,___(2B)___);
4     (_____________________(3)_____________________);
5     strcat(___(4A)___, ___(4B)___);
6     return heapstr;
7 }
```

Example usage:

```
char *str = strdup("Hello ");
str = strcat_extend(str, "world!");
printf("%s\n", str);
free(str);
```

strcat_extend

Write a function that takes in a heap-allocated **str1,** enlarges it, and concatenates **str2** onto it.

```
1 char *strcat_extend(char *heap_str, const char *concat_str) {
2     int new_length = strlen(heap_str) + strlen(concat_str) + 1;
3     heap_str = realloc(heap_str, new_length);
4     assert(heap_str != NULL);
5     strcat(heap_str, concat_str);
6     return heapstr;
7 }
```

Example usage:

```
char *str = strdup("Hello ");
str = strcat_extend(str, "world!");
printf("%s\n", str);
free(str);
```