CS 161
Intro to CS I

Finish Recursion/Begin Memory Model

Odds and Ends

- Assignment 5 posted
- Assignment 4 demo this week

Avg

- 1 credit hour of lecture/course is 3 hours outside the course
- Poor planning on your part does not constitute an emergancy on mine!
- KISS!

Iterative Factorial

Oregon State University
College of Engineering

factorial(0) = 1;
factorial(n) = n*n-1*n-2*…*n-(n-1)*1;

```
long factorial(int n) {
        long fact;
        if(n==0)
           fact=1;
        else
           for(fact=n; n > 1; n--)
              fact=fact*(n-1);
        return fact;
}
```

Oregon State University
College of Engineering

Recursive Factorial

```
factorial(0) = 1;
factorial(n) = n*factorial(n-1);
```

base case

getting you closer to base case

```
long factorial(int n) {
    if (n == 0)        // Base case
        return 1;
    else
        return n * factorial(n - 1);     // Recursive call
}
```

Computing Factorial Iteratively

Oregon State University
College of Engineering

factorial(4)

```
factorial(0) = 1;
factorial(n) = n*(n-1)*...*2*1;
```

Computing Factorial Iteratively

Oregon State University
College of Engineering

factorial(0) = 1;
factorial(n) = n*(n-1)*…*2*1;

factorial(4) = 4 * 3

Computing Factorial Iteratively

factorial(0) = 1;
factorial(n) = n*(n-1)*…*2*1;

factorial(4) = 4 * 3
= 12 * 2

Computing Factorial Iteratively

Oregon State University
College of Engineering

```
factorial(0) = 1;
factorial(n) = n*(n-1)*...*2*1;
```

factorial(4) = 4 * 3
= 12 * 2
= 24 * 1

Computing Factorial Iteratively

factorial(0) = 1;
factorial(n) = n*(n-1)*…*2*1;

factorial(4) = 4 * 3
= 12 * 2
= 24 * 1
= 24

Computing Factorial Recursively

Oregon State University
College of Engineering

```
factorial(0) = 1;
factorial(n) = n*factorial(n-1);
```

factorial(4)

Computing Factorial Recursively

Oregon State University
College of Engineering

```
factorial(0) = 1;
factorial(n) = n*factorial(n-1);
```

factorial(4) = 4 * factorial(3)

Computing Factorial Recursively


```
factorial(0) = 1;
factorial(n) = n*factorial(n-1);
```

factorial(4) = 4 * factorial(3)
= 4 * (3 * factorial(2))

Computing Factorial Recursively


```
factorial(0) = 1;
factorial(n) = n*factorial(n-1);
```

factorial(4) = 4 * factorial(3)
= 4 * (3 * factorial(2))
= 4 * (3 * (2 * factorial(1)))

Computing Factorial Recursively

Oregon State University
College of Engineering

```
factorial(0) = 1;
factorial(n) = n*factorial(n-1);
```

```
factorial(4) = 4 * factorial(3)
             = 4 * ( 3 * factorial(2))
             = 4 * ( 3 * (2 * factorial(1)))
             = 4 * ( 3 * ( 2 * (1 * factorial(0))))
```

Computing Factorial Recursively

Oregon State University
College of Engineering

```
factorial(0) = 1;
factorial(n) = n*factorial(n-1);
```

```
factorial(4) = 4 * factorial(3)
             = 4 * (3 * factorial(2))
             = 4 * ( 3 * (2 * factorial(1)))
             = 4 * ( 3 * ( 2 * (1 * factorial(0))))
             = 4 * ( 3 * ( 2 * (1 *1)))
```

Computing Factorial Recursively

Oregon State University
College of Engineering

```
factorial(0) = 1;
factorial(n) = n*factorial(n-1);
```

factorial(4) = 4 * factorial(3)
= 4 * (3 * factorial(2))
= 4 * (3 * (2 * factorial(1)))
= 4 * (3 * (2 * (1 * factorial(0))))
= 4 * (3 * (2 * (1 *1)))
= 4 * (3 * (2 * 1))

Computing Factorial Recursively

Oregon State University
College of Engineering

```
factorial(0) = 1;
factorial(n) = n*factorial(n-1);
```

factorial(4) = 4 * factorial(3)
= 4 * (3 * factorial(2))
= 4 * (3 * (2 * factorial(1)))
= 4 * (3 * (2 * (1 * factorial(0))))
= 4 * (3 * (2 * (1 *1)))
= 4 * (3 * (2 * 1))
= 4 * (3 * 2)

Computing Factorial Recursively


```
factorial(0) = 1;
factorial(n) = n*factorial(n-1);
```

factorial(4) = 4 * factorial(3)
= 4 * (3 * factorial(2))
= 4 * (3 * (2 * factorial(1)))
= 4 * (3 * (2 * (1 * factorial(0))))
= 4 * (3 * (2 * (1 *1)))
= 4 * (3 * (2 * 1))
= 4 * (3 * 2)
= 4 * 6

Computing Factorial Recursively

Oregon State University
College of Engineering

```
factorial(0) = 1;
factorial(n) = n*factorial(n-1);
```

```
factorial(4) = 4 * factorial(3)
             = 4 * (3 * factorial(2))
             = 4 * ( 3 * (2 * factorial(1)))
             = 4 * ( 3 * ( 2 * (1 * factorial(0))))
             = 4 * ( 3 * ( 2 * (1 *1)))
             = 4 * ( 3 * ( 2 * 1))
             = 4 * (3 * 2)
             = 4 * 6
             = 24
```

Differences

Oregon State University
College of Engineering

- Pros
  - Readability
- Cons
  - Efficiency
  - Memory

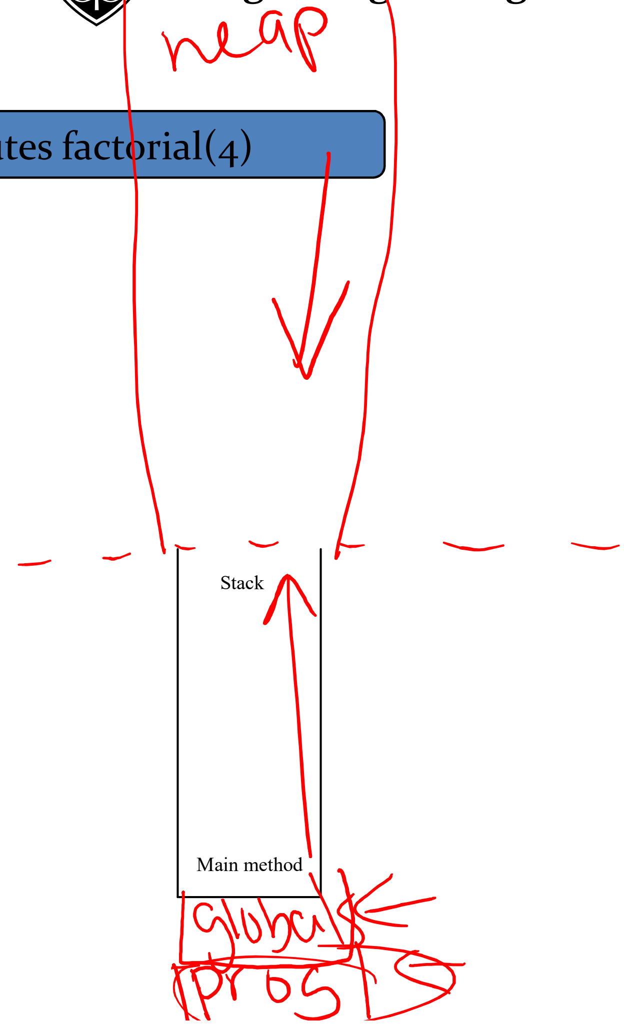
You have to have shallow depth

not too many recursive calls.

Recursive Factorial

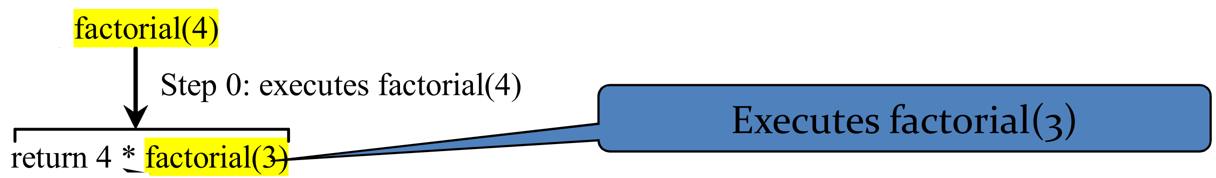
Executes factorial(4)

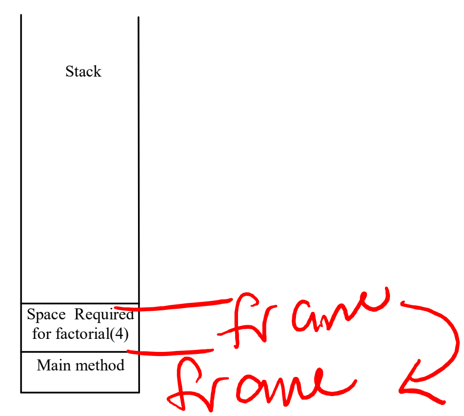
factorial(4)



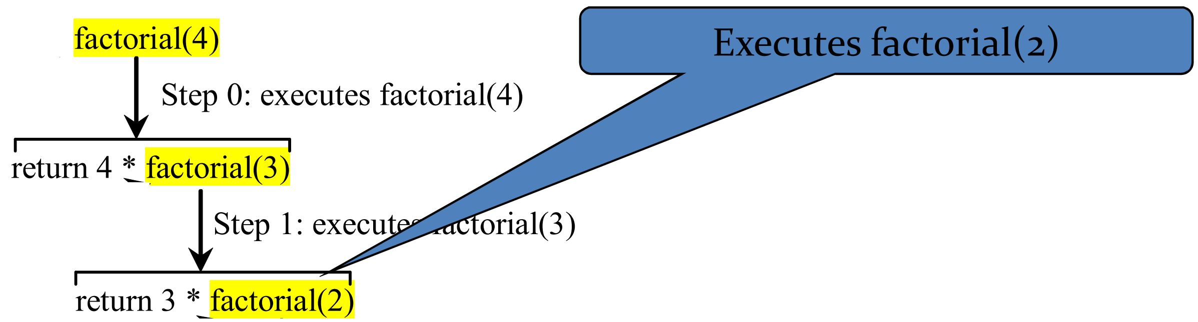
Oregon State University
College of Engineering

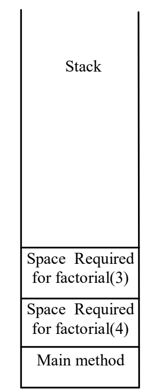
Recursive Factorial



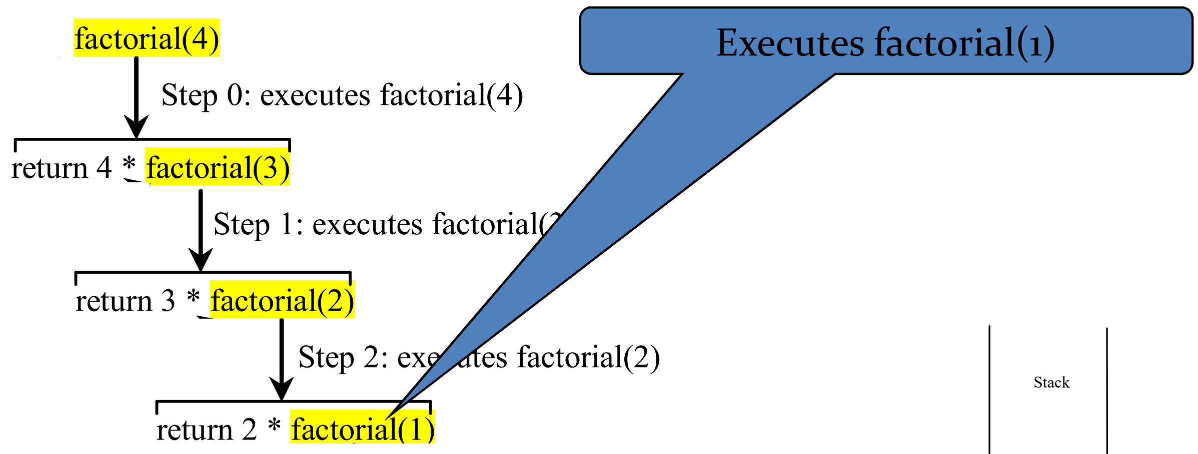


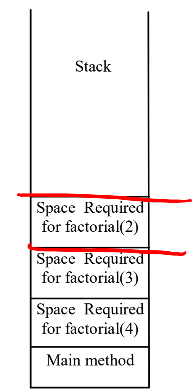
Recursive Factorial



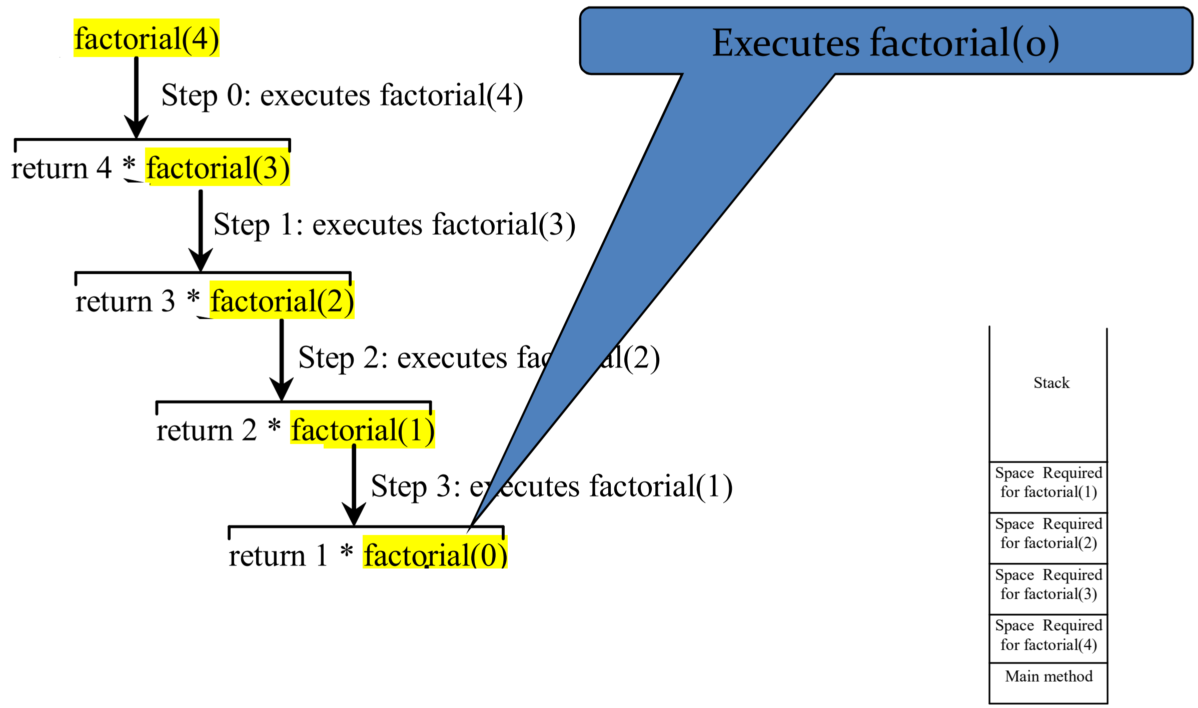


Recursive Factorial

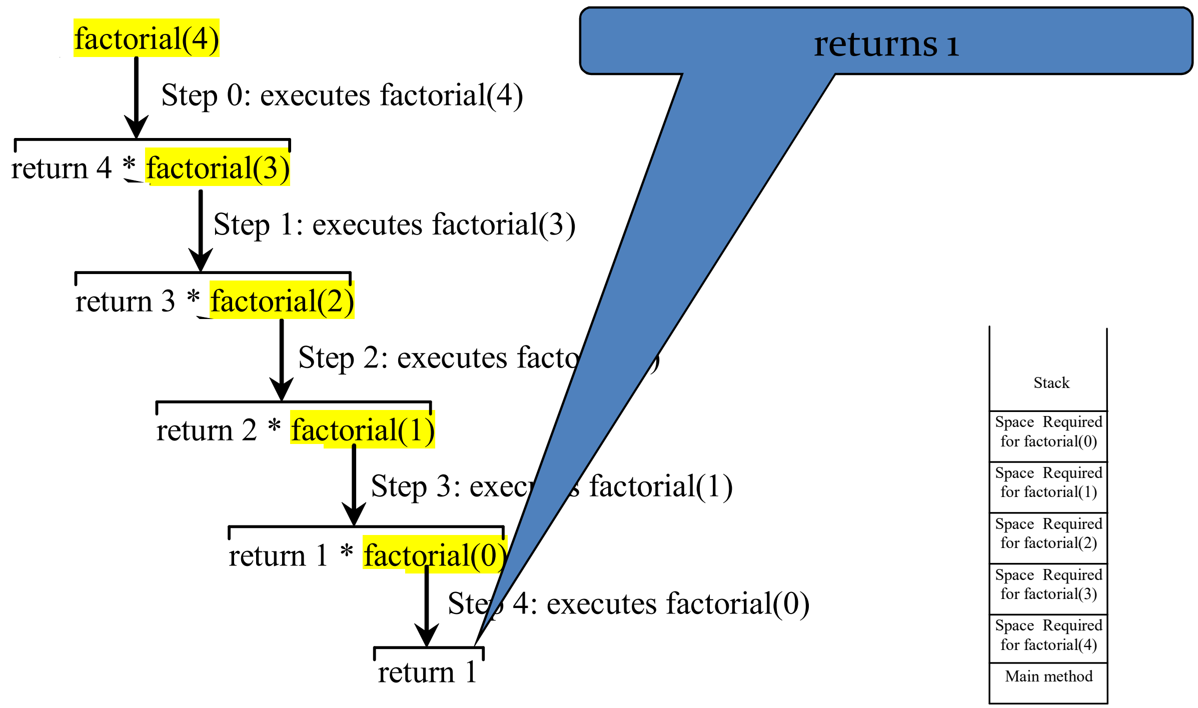




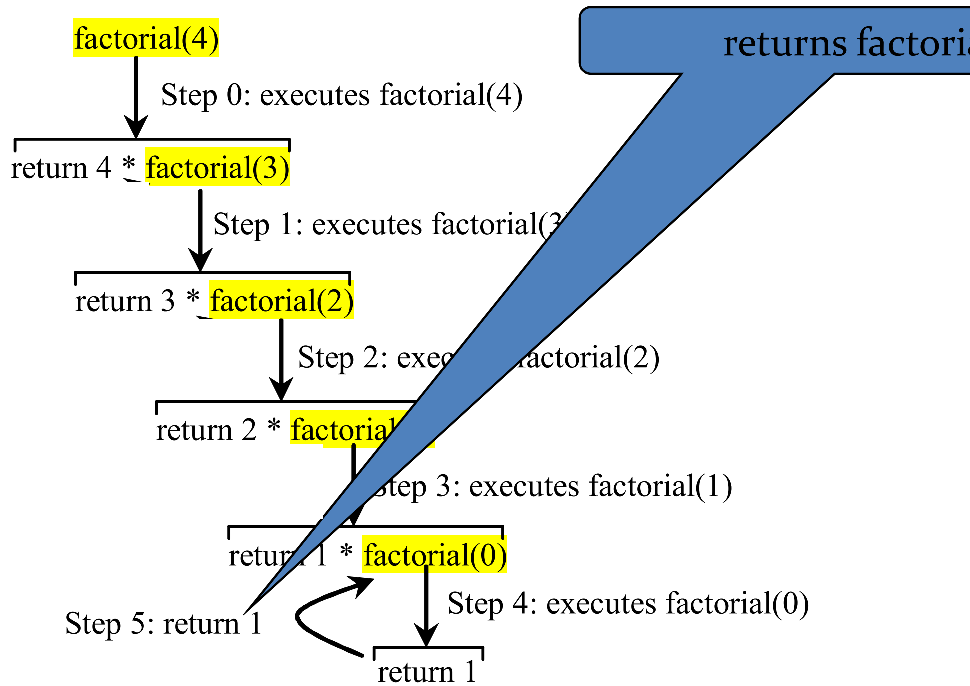
Recursive Factorial

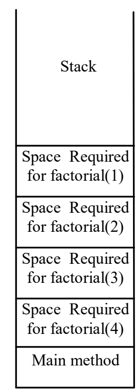


Recursive Factorial

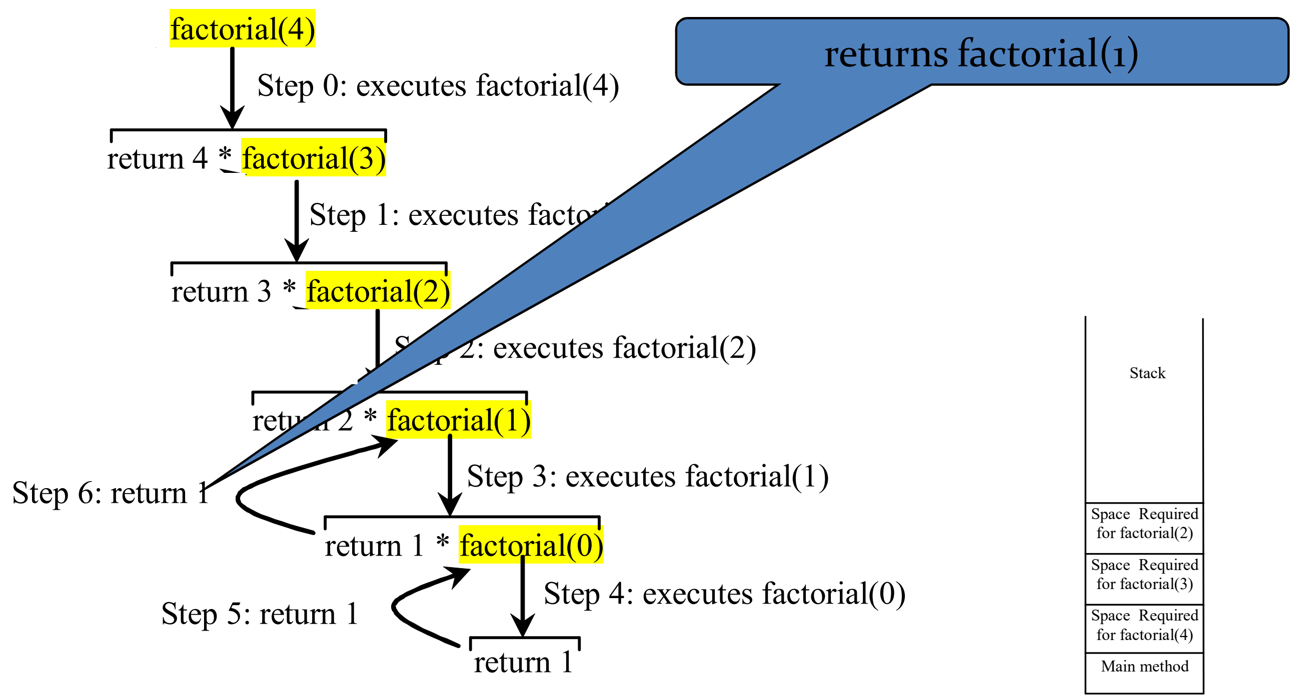


Recursive Factorial

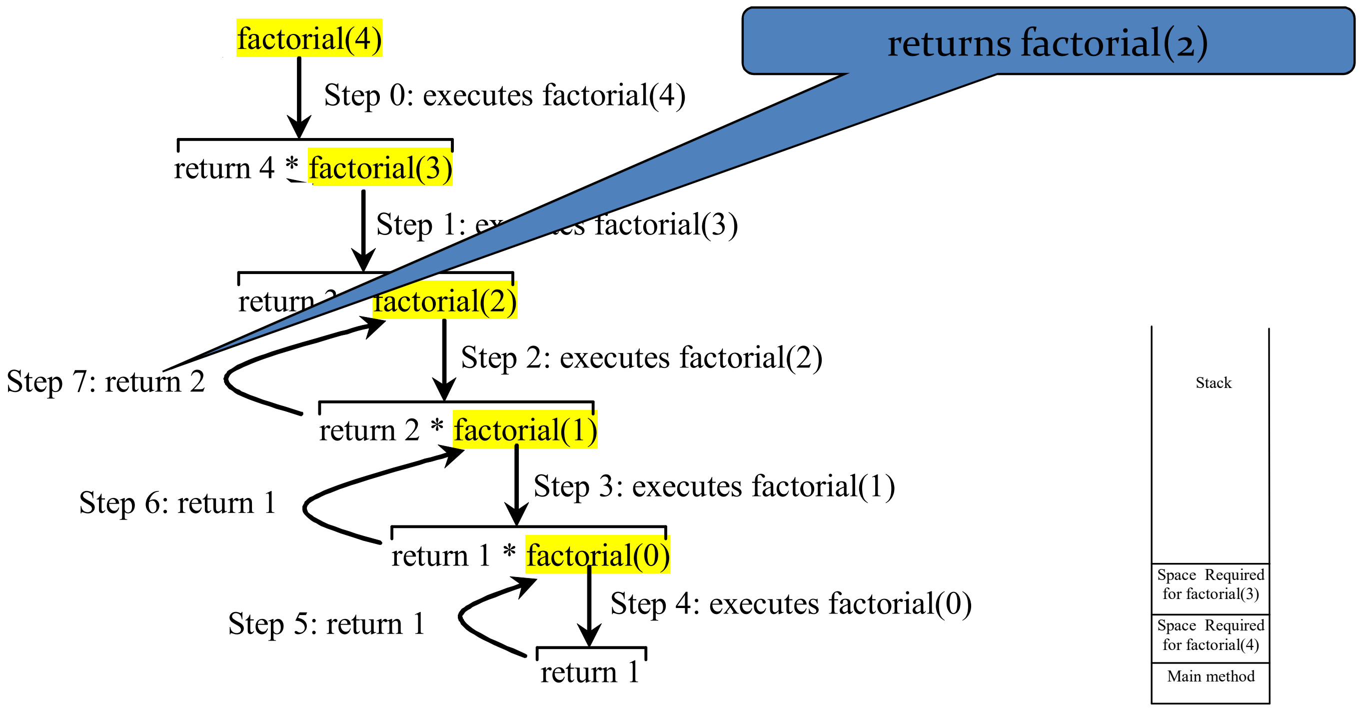




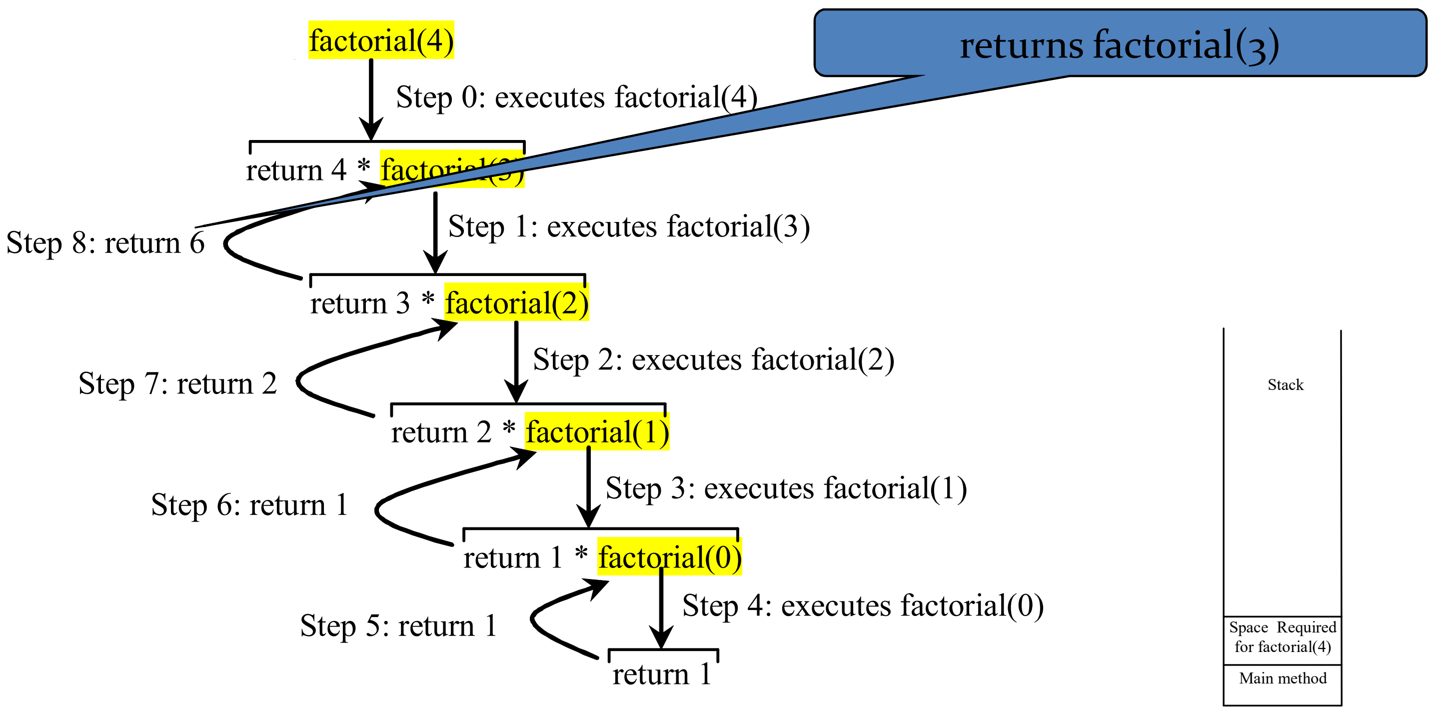
Recursive Factorial



Recursive Factorial

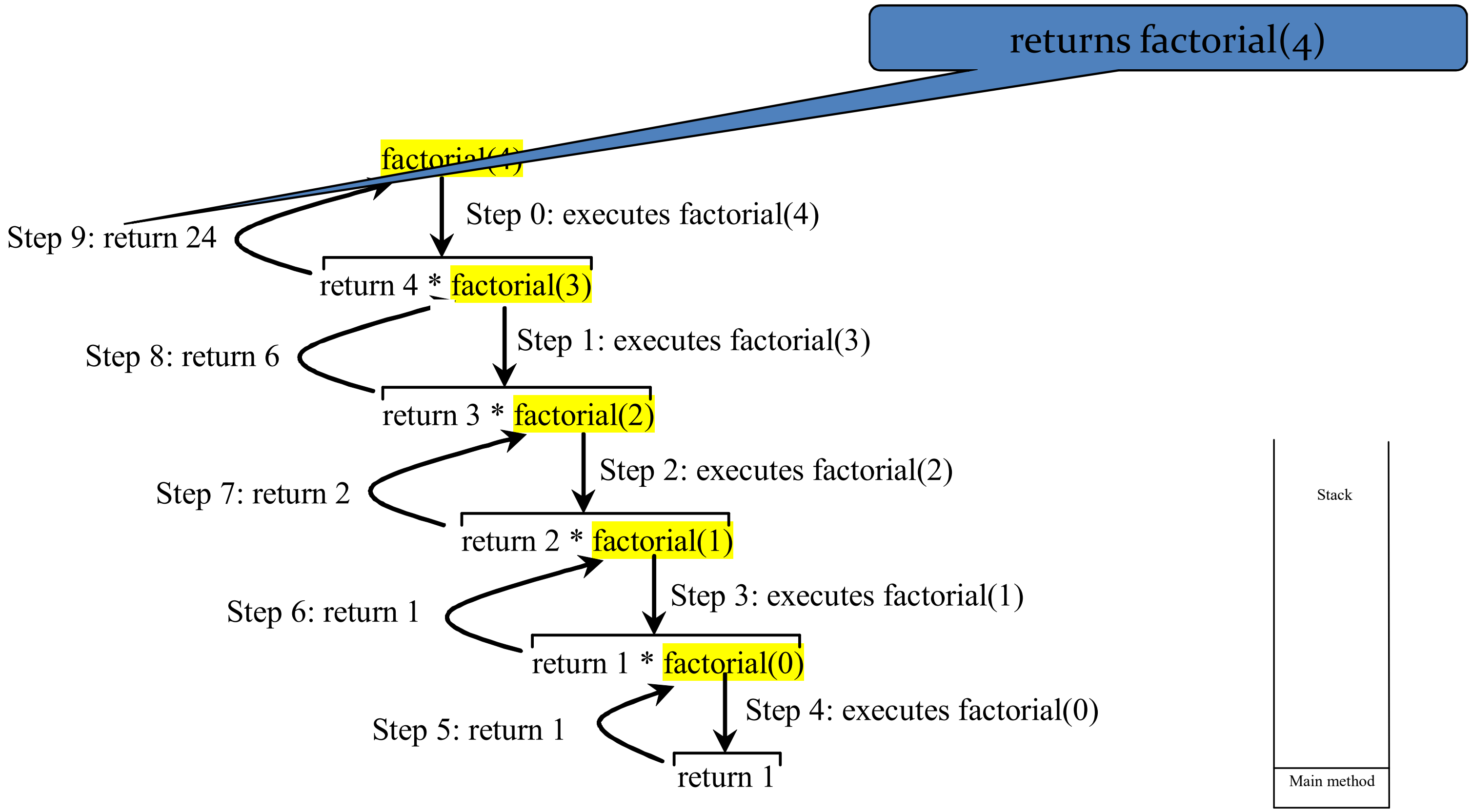


Recursive Factorial



Recursive Factorial

Oregon State University
College of Engineering



In-class Exercise #4

- ~~Get into groups of 4 – 5.~~
- Write your own recursive *int pwr()* function that takes two integers as arguments and returns the integer result.
  - What does the function prototype look like?
  - Now, write the function definition…

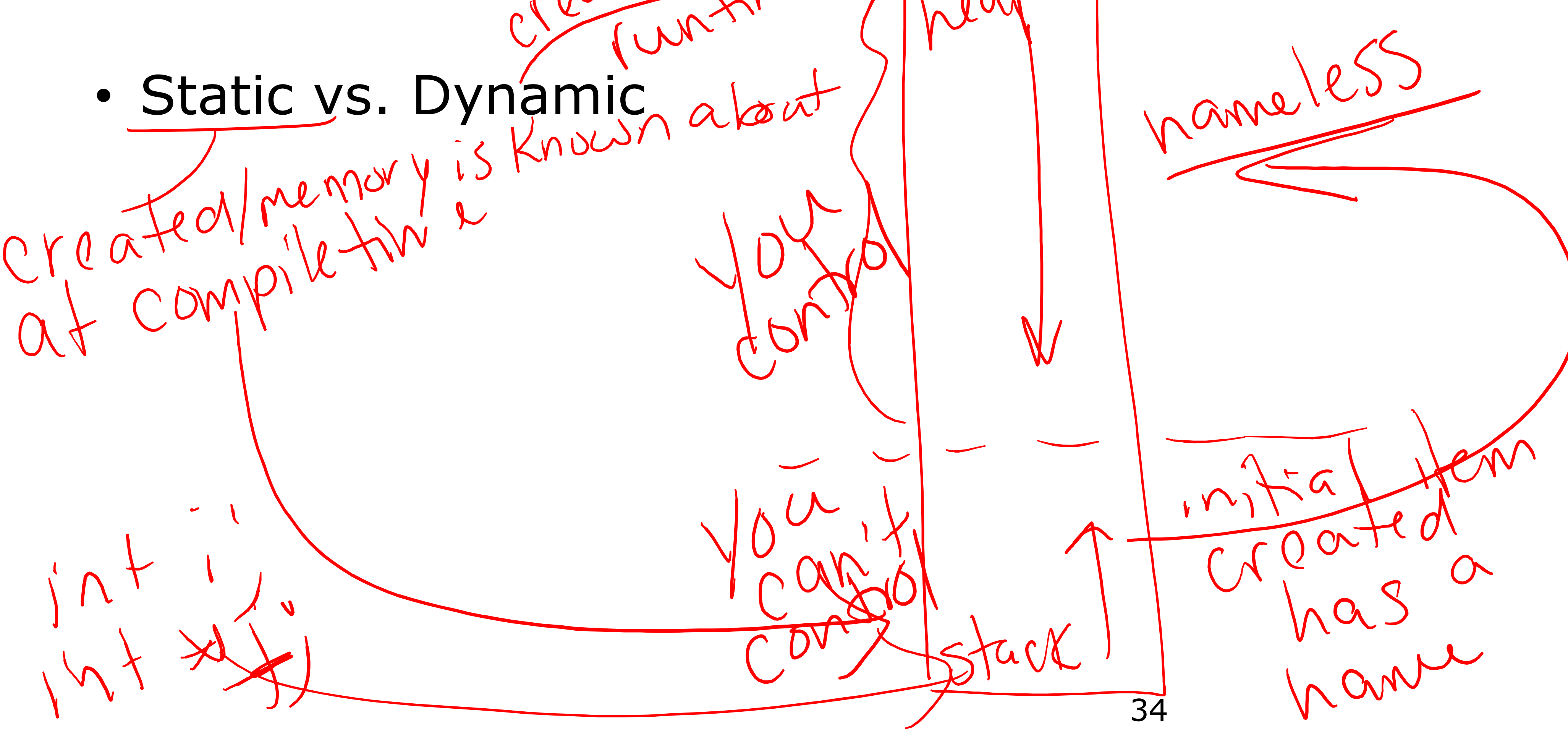
4. ENGR

```cpp
#include <iostream>

using namespace std;

int pwr(int base, int exp) {
   int result=1;

   for(int i=0; i<exp; i++) {
      result=result*base;
   }

   return result;
}
int pwr_r(int base, int exp) {
   if(exp==0)  //base case
      return 1;
   else
      return base*pwr_r(base, exp-1); //get us closer to base case
}

int main() {

   cout << pwr(2,1000000) << endl;
   cout << pwr_r(2,1000000) << endl;  //too deep of recursion, blow stack

-- INSERT --                                            24,74          Top
```

Oregon State University
College of Engineering

Stack vs. Heap

- Static vs. Dynamic



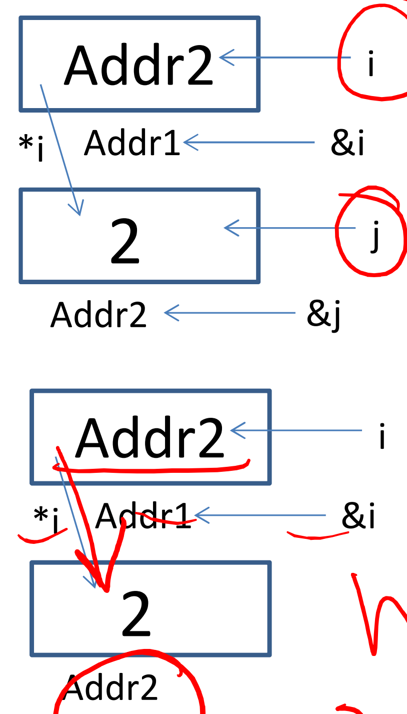
Static vs. Dynamic

- Static Semantics
  - Assign address of variable

```
int *i, j=2;
i=&j;
```

- Dynamic Semantics
  - Create memory
  - Assign memory to pointer

```
int *i=NULL;
i=new int;
*i=2;
```



What About Memory Leaks?

- What happens here…

```
…
int main () {
  int *i=NULL;    //created in main function
  while(1) {
      i = new int;
   }
}
```

Fixing Memory Leaks…

Oregon State University College of Engineering

- What happens here…

```
…
int main () {
 int *i=NULL;    //created in main function
 while(1) {
  i = new int;
  delete i; //free memory that i points to, preventing mem leaks
 }
}
```

cout<<i