CS 161
Intro to CS I

Recursion

Oregon State University

Example: Factorial

- Definition

  0!=1;

  n!=n * (n-1) * … * (n-(n-1)) * 1 = n * (n-1)! ; n > 0

  iterative — recursive

Iterative Factorial

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;
}
```

Recursive Factorial

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

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

Computing Factorial Iteratively

factorial(4)

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

Computing Factorial Iteratively

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

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

factorial(4)

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

Computing Factorial Recursively

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

```
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

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)))

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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))

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)

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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

```
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

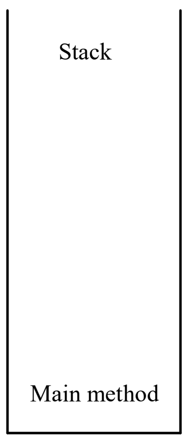
- Pros
  - Readability
- Cons
  - Efficiency
  - Memory

} not a reason to avoid recursion

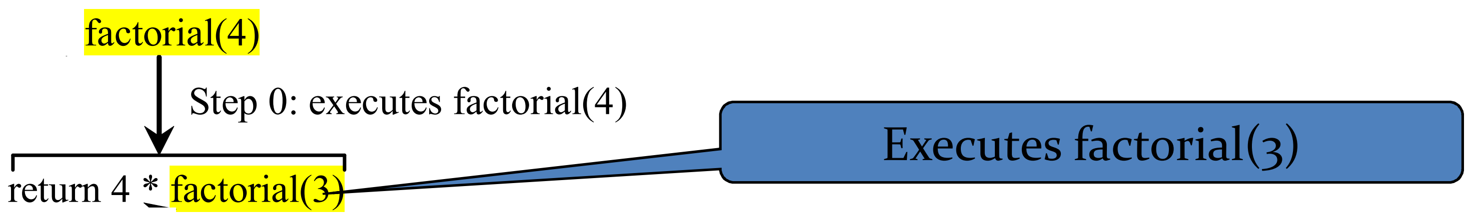
Recursive Factorial

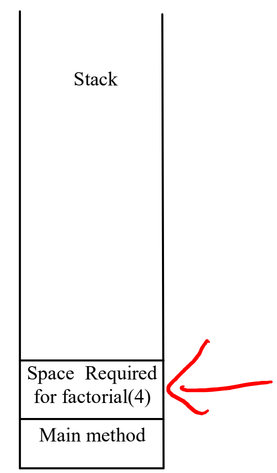
Executes factorial(4)

factorial(4)

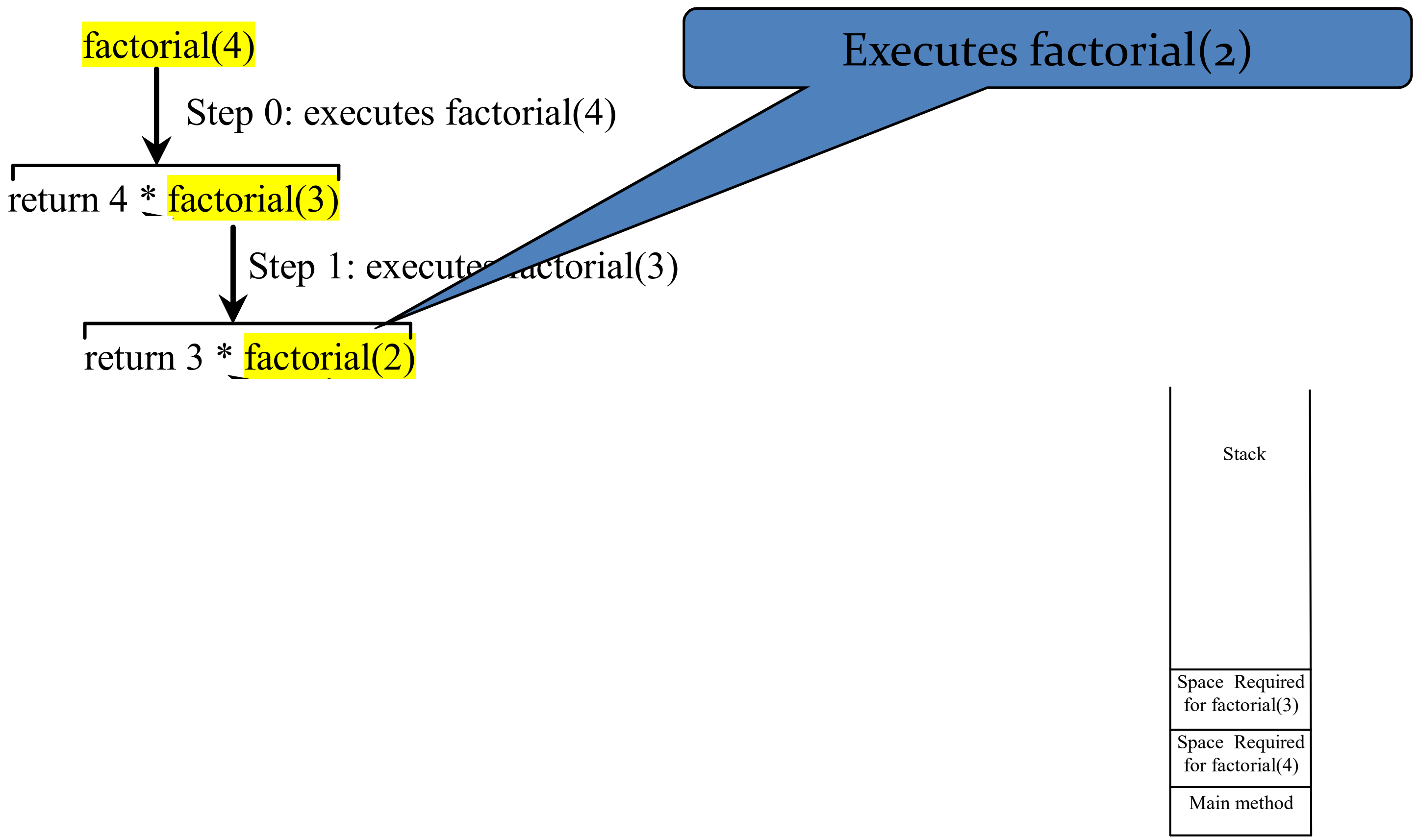


Recursive Factorial

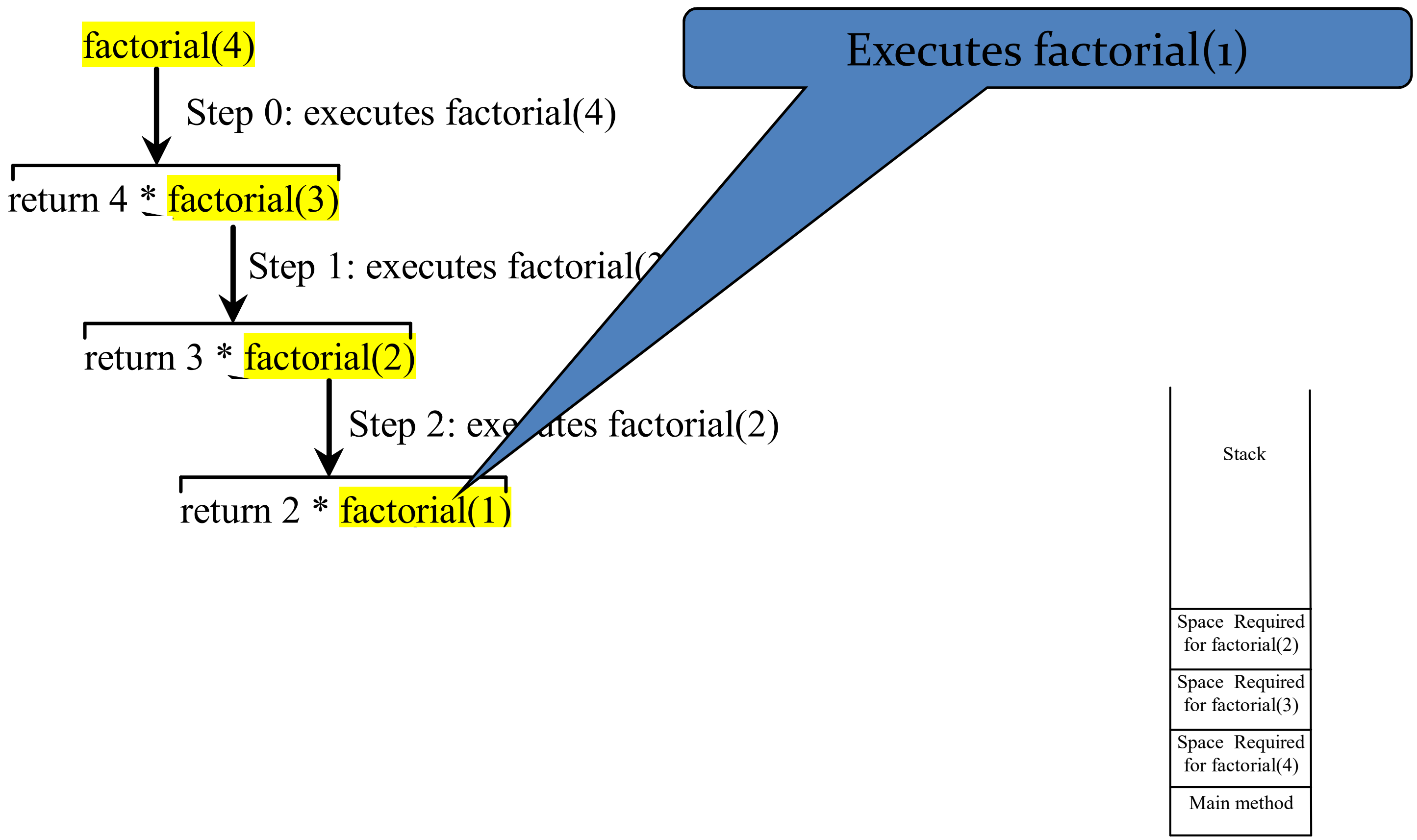




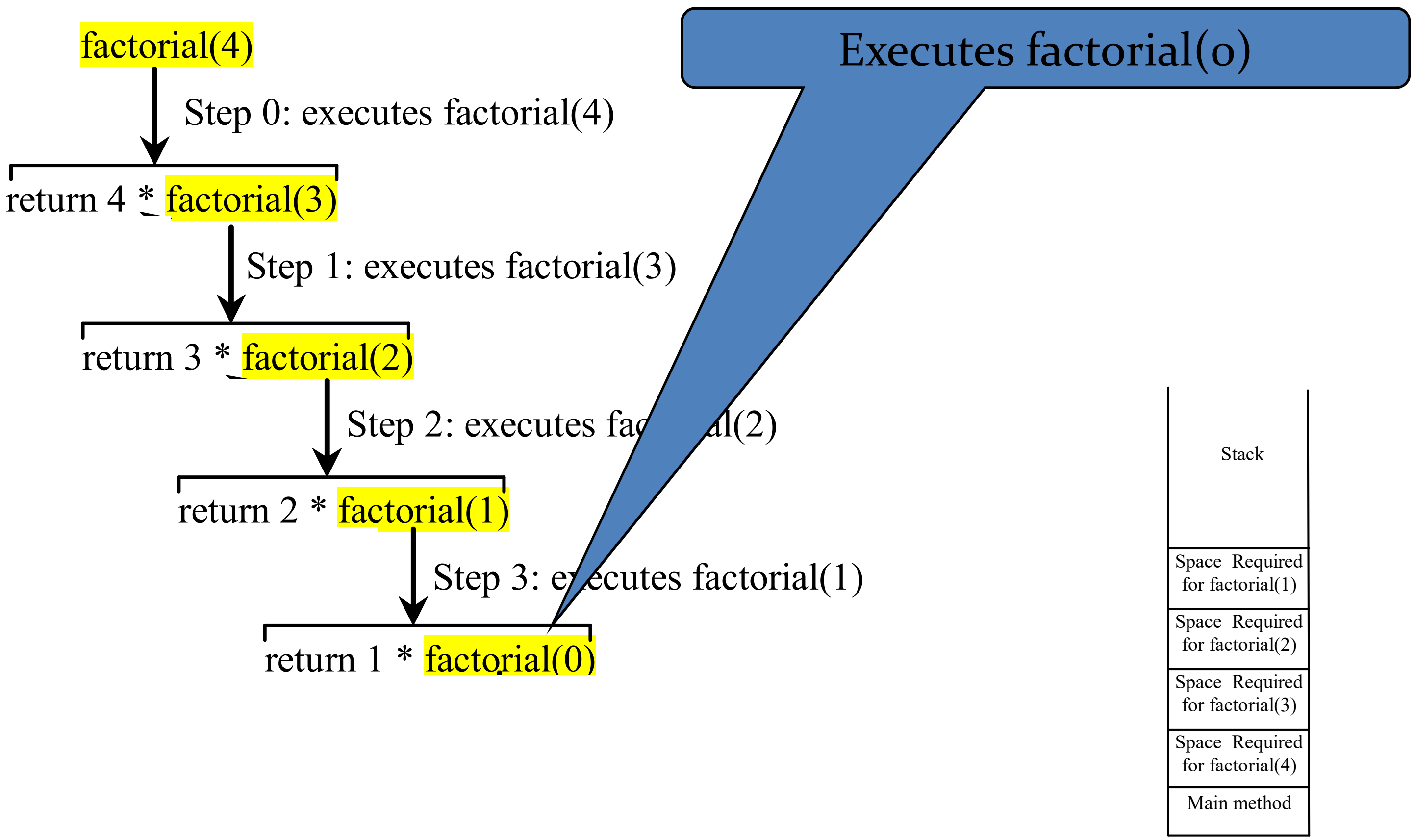
Recursive Factorial



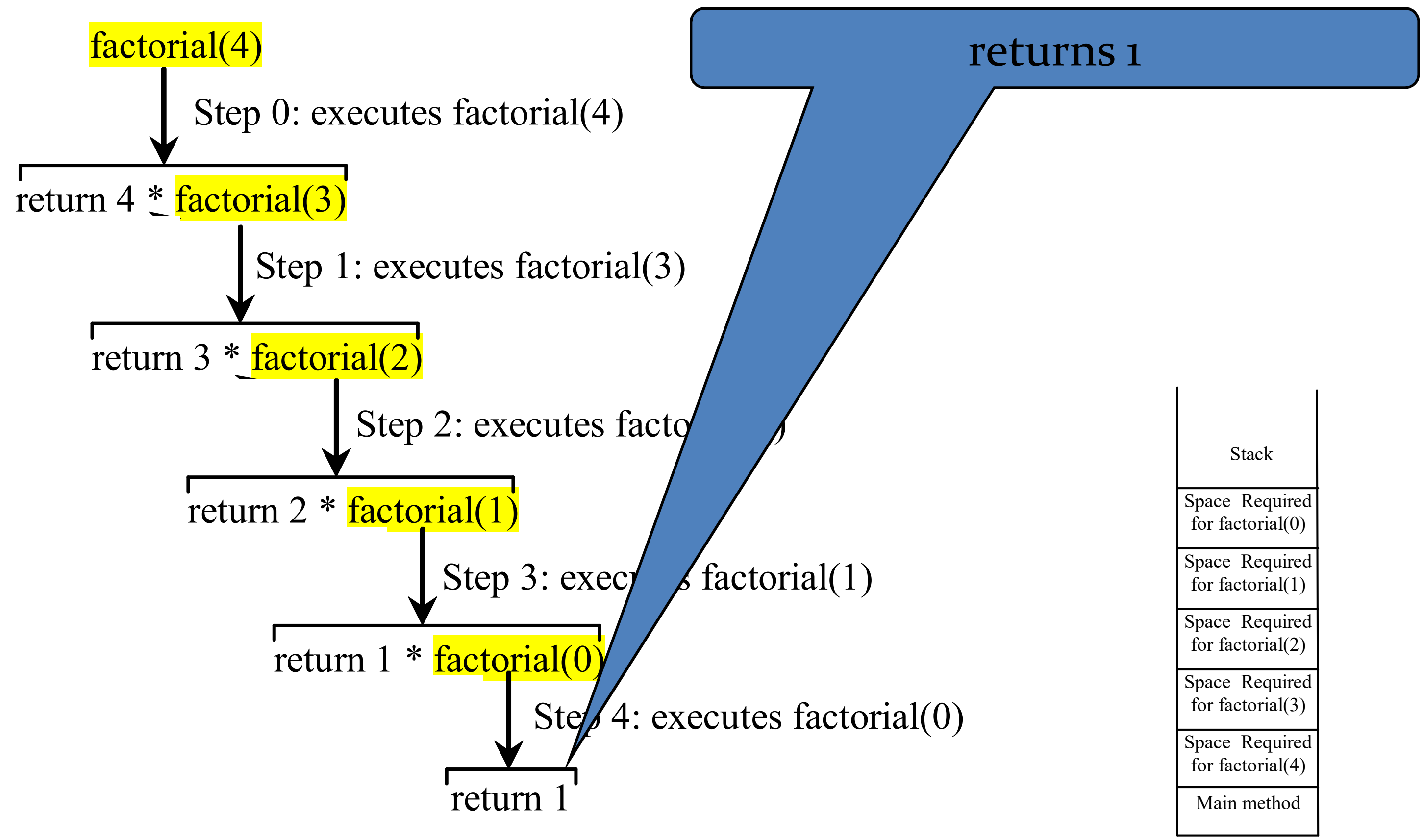
Recursive Factorial



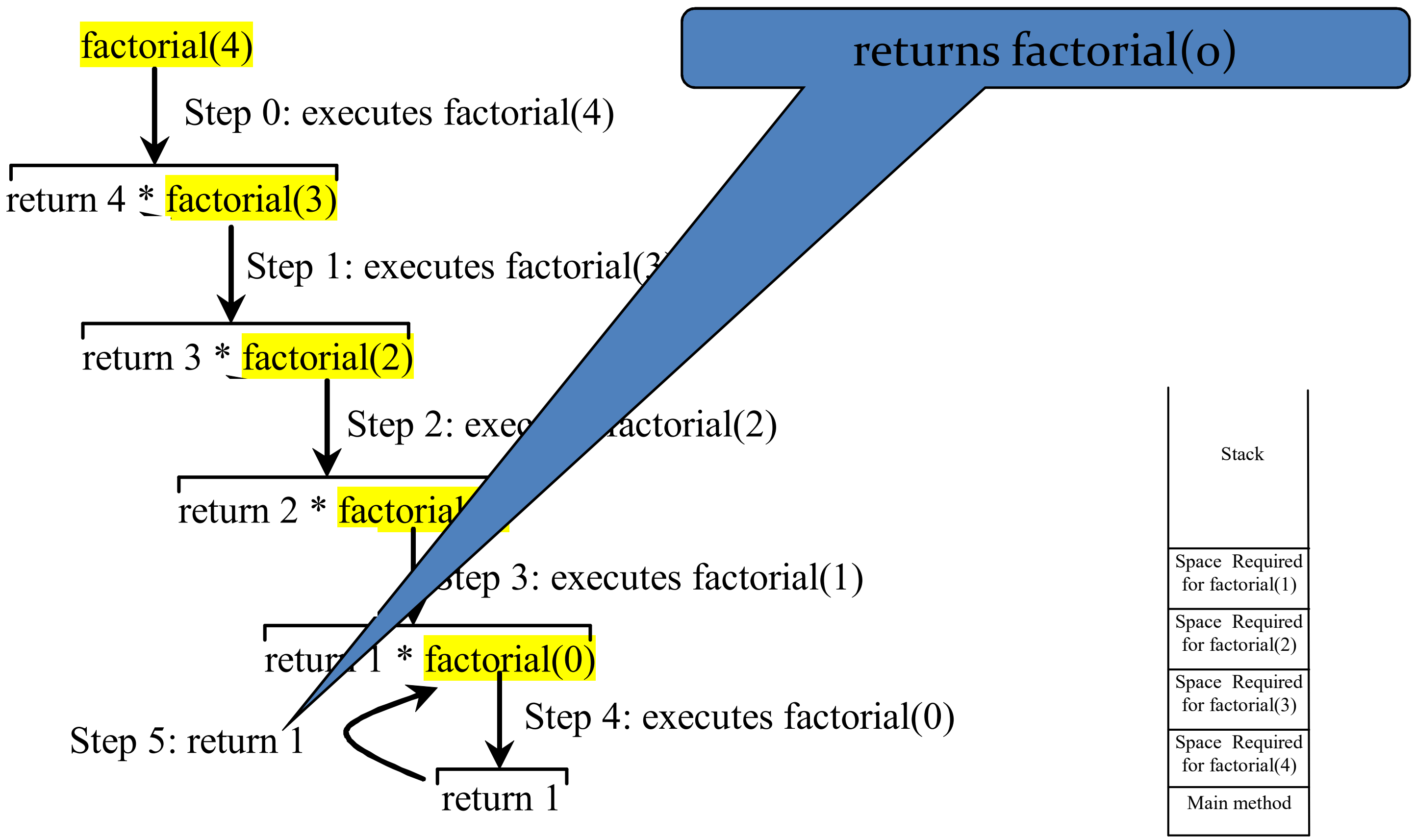
Recursive Factorial



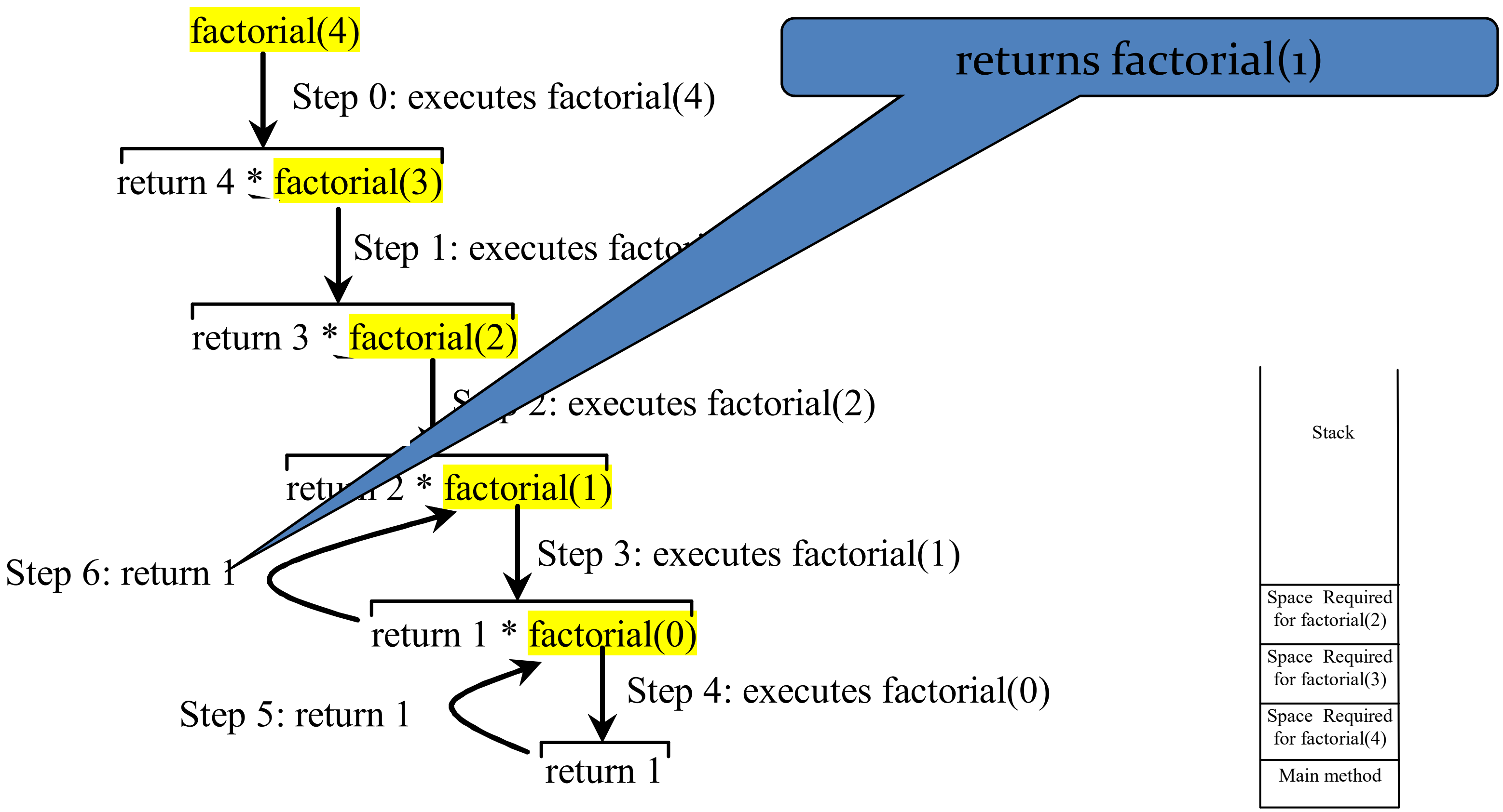
Recursive Factorial



Recursive Factorial



Recursive Factorial



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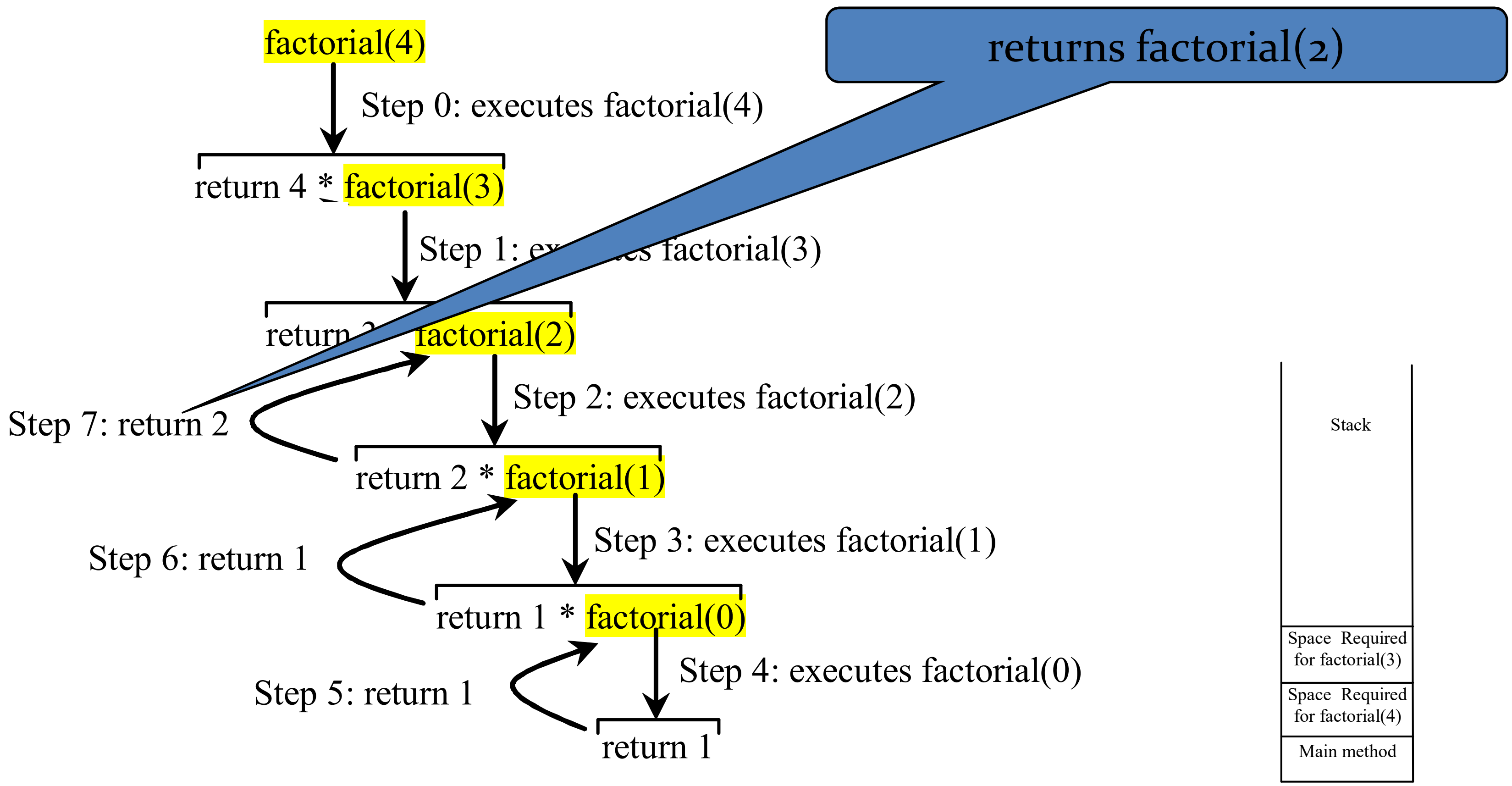
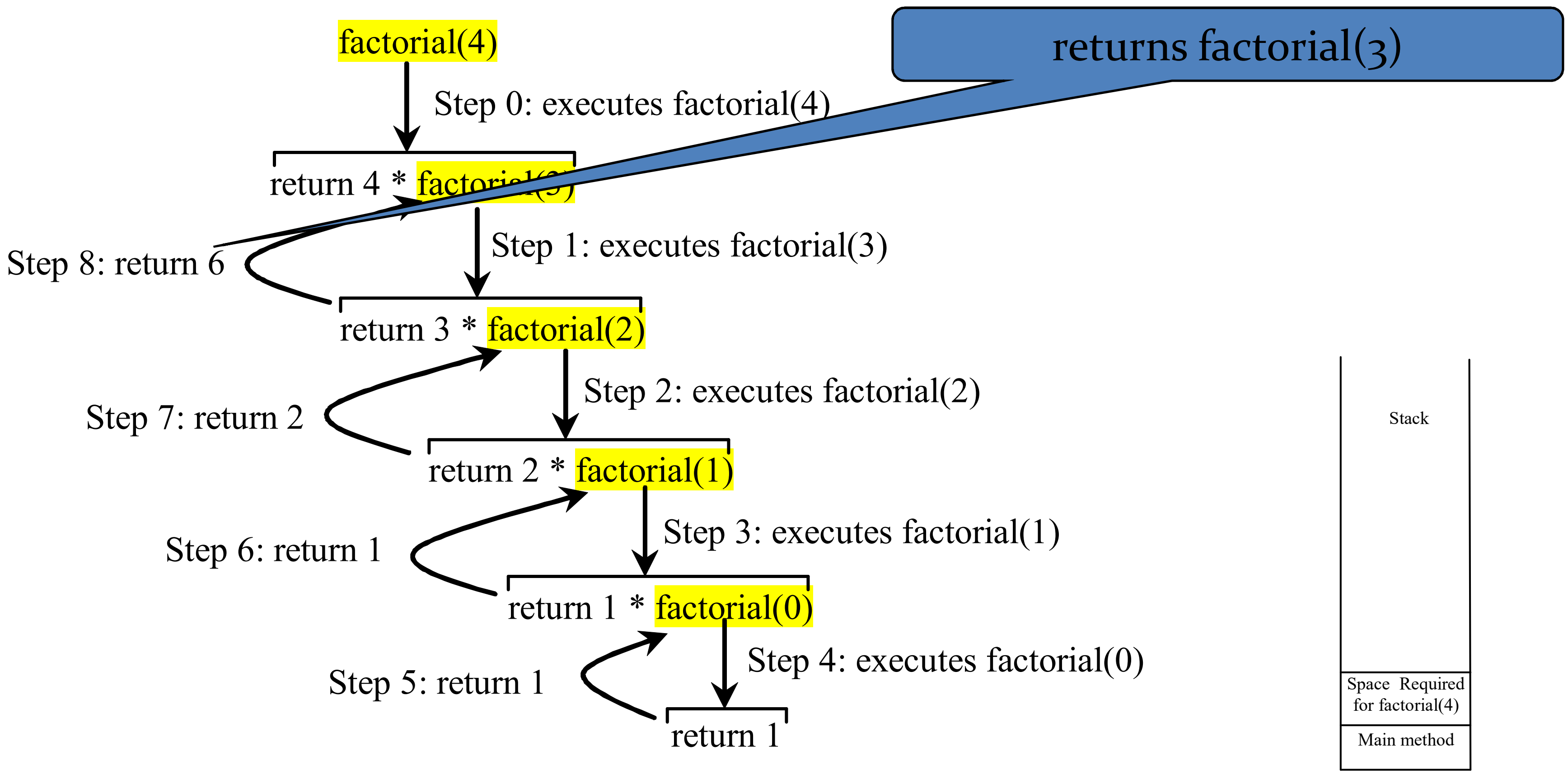
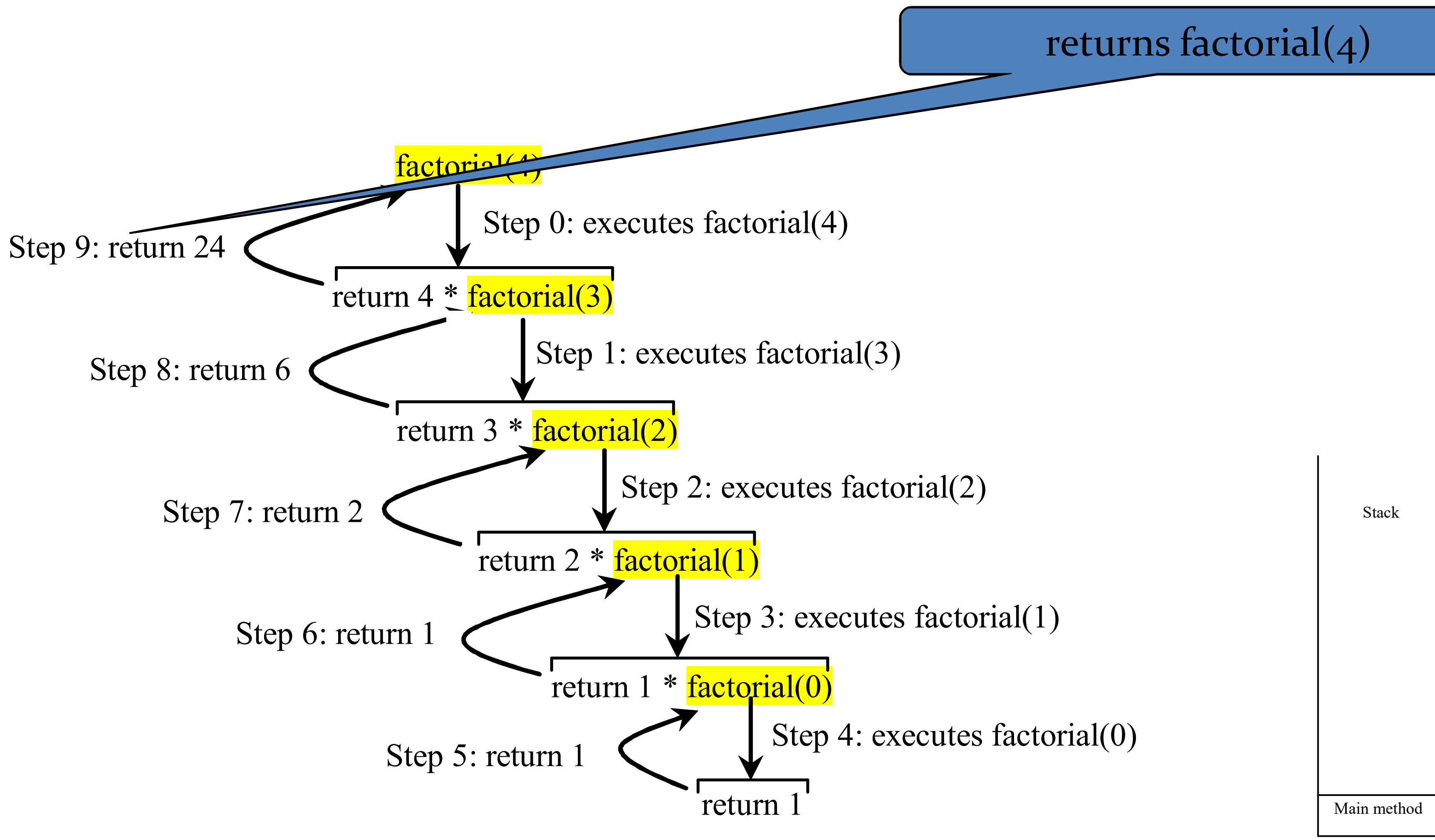
Recursive Factorial



Recursive Factorial



Recursive Factorial



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…

2. ENGR

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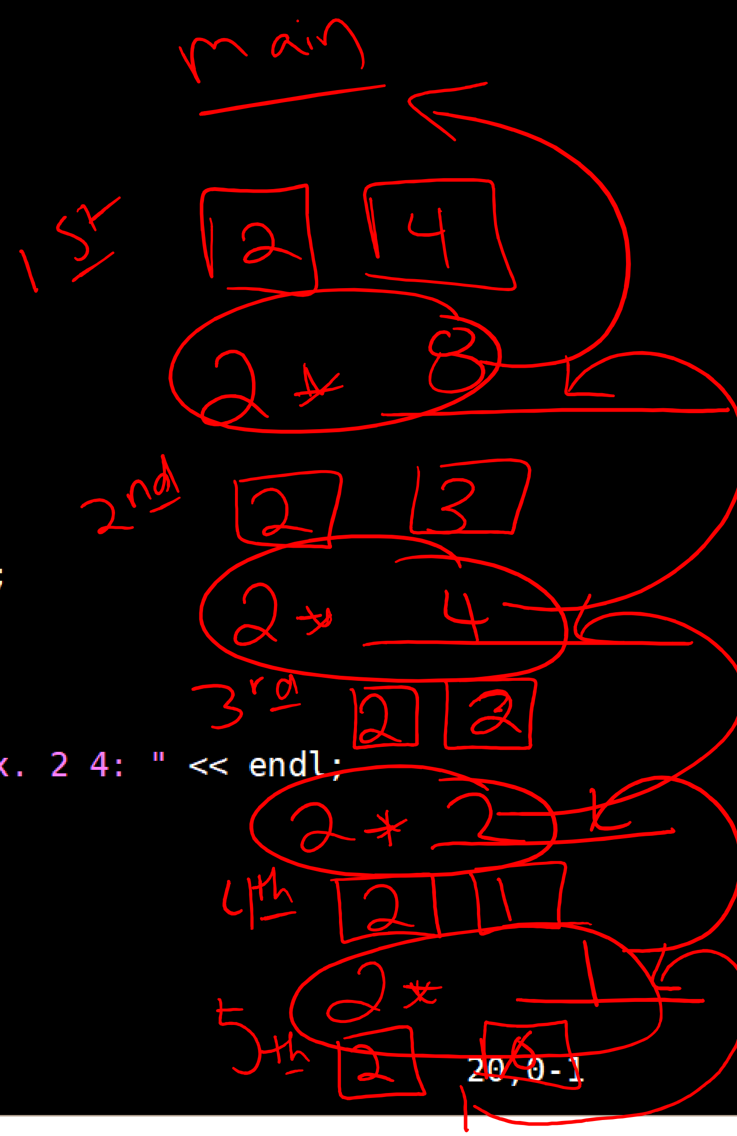
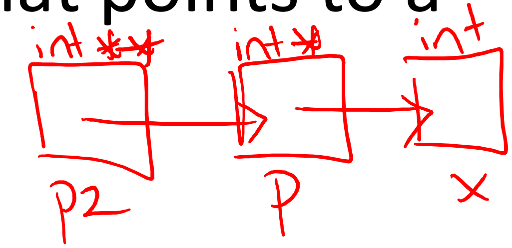
```
#include <iostream>

using namespace std;

int power(int base, int exponent) {
   int p=1;
   for(int i=0; i<exponent; i++)
      p*=base;

   return p;
}

int pwr(int base, int exponent) {
   //base
   if(exponent==0)
      return 1;
   else
      return base*pwr(base,exponent-1);
}

int main() {
   int base, exp;
   cout << "Enter base and exponent, ex. 2 4: " << endl;
   cin >> base;
   cin >> exp;
   cout << power(base, exp) << endl;
   cout << pwr(base, exp) << endl;

   return 0;
}
```



20,0-1 All

In-class Exercise
Pointers vs. References

- What if you made a pointer (p2) that points to a pointer (p) to an int (x)?
  - What would the picture look like?
  - Write the code for this picture.



int x, *p, **p2;
p = &x;
p2 = &p;

*p gives contents of x
*p2 gives contents of p, addr. of x
**p2 gives contents of x

- Can you make this same picture for references? no!
  - What if you had two references, r and r2?