CSCI 127: Joy and Beauty of Data

Lecture ~~12~~ 9: Recursion

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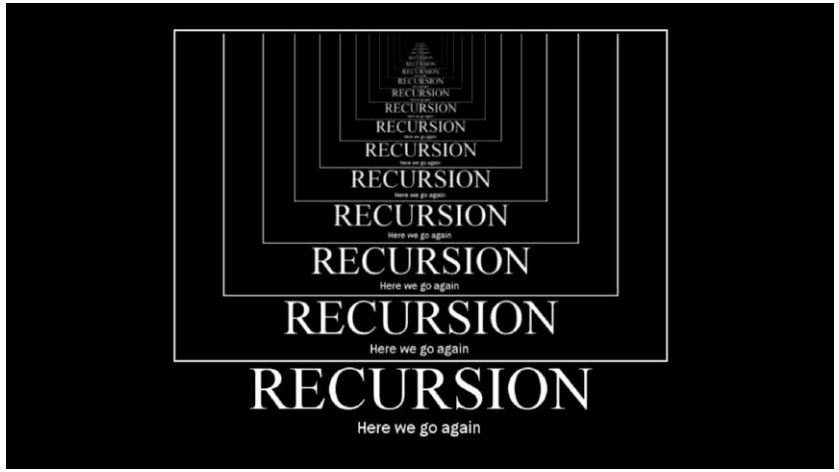
Summer 2021

https://reesep.github.io/classes/summer2021/127/main.html

Recursion

Recursion is a method of solving a problem that involves solving smaller instances of the same problem using the same function

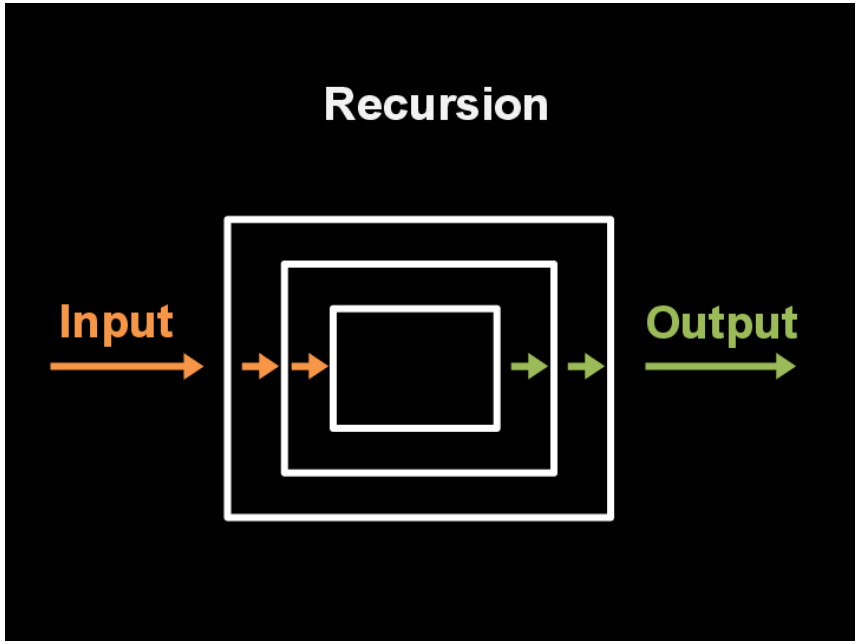


Can be very challenging…..

Recursion Requirements

1. Base Case
   - The “stopping point” for your recursive calls

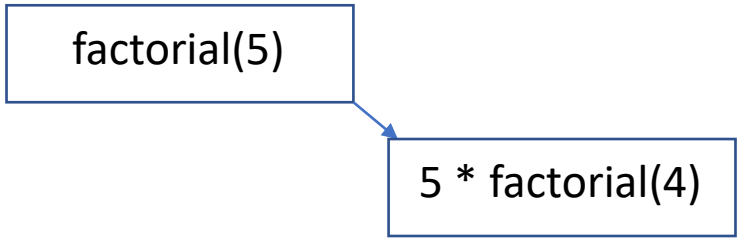
2. Recursive Case
   - Call the function again and solve a smaller problem



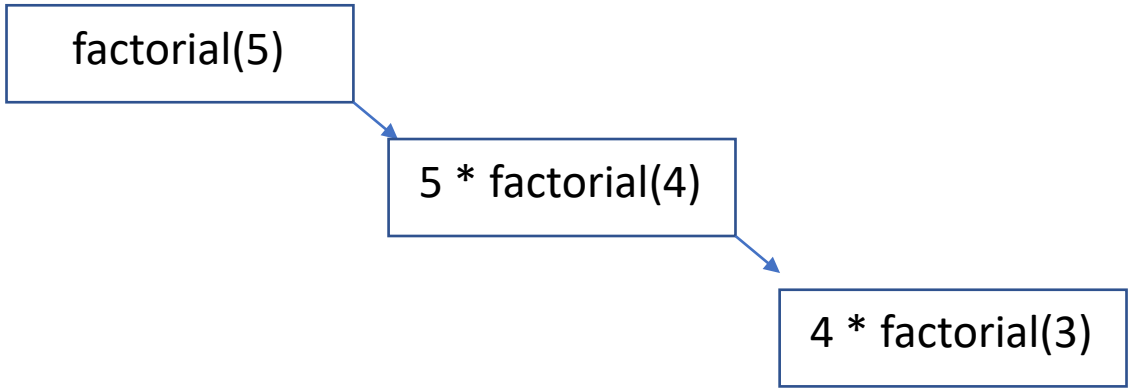
Factorial

factorial(5)

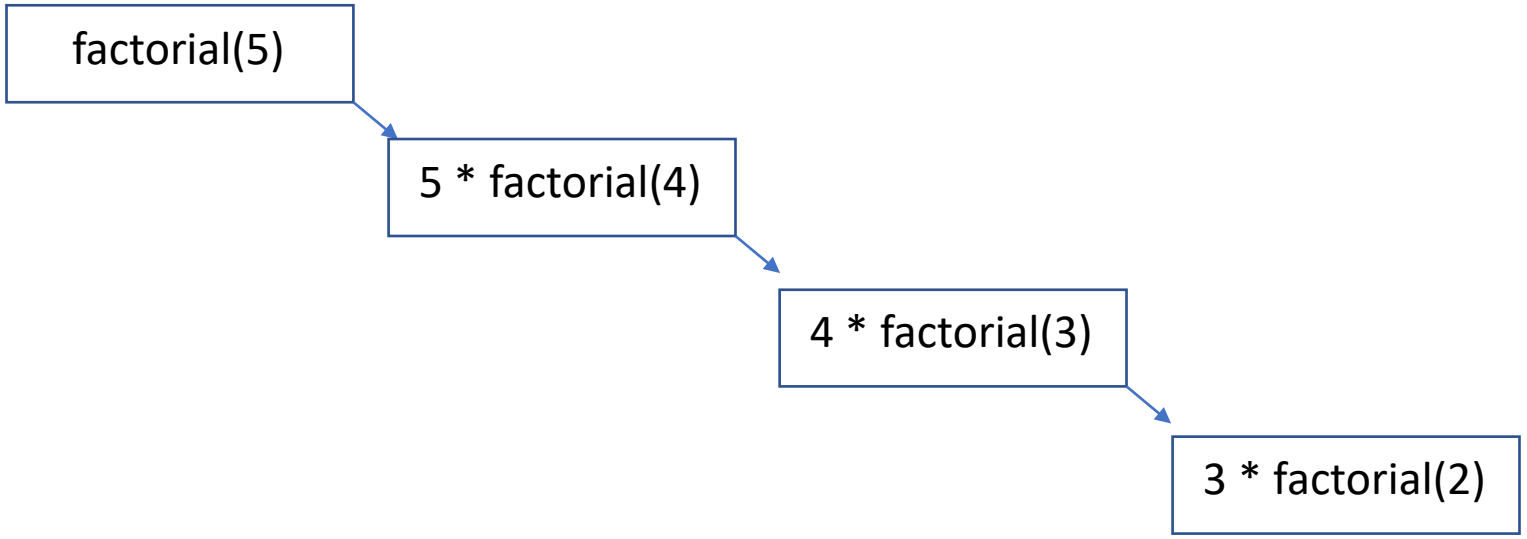
Factorial



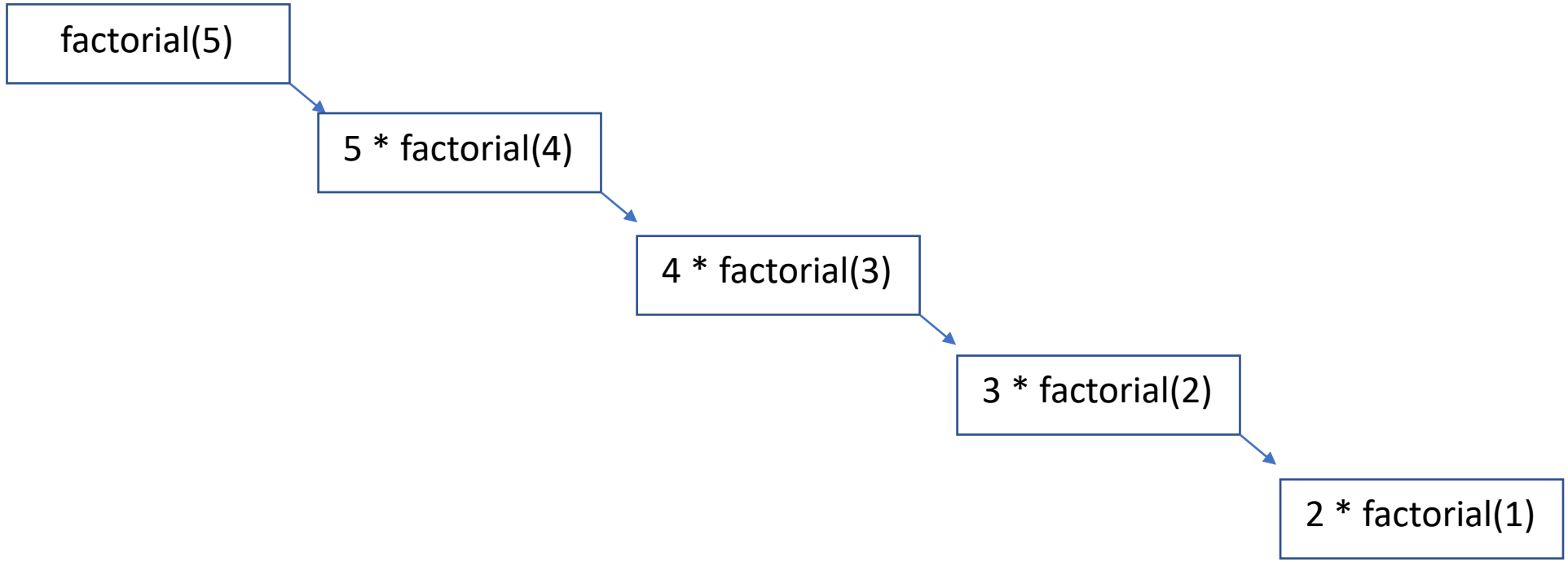
Factorial



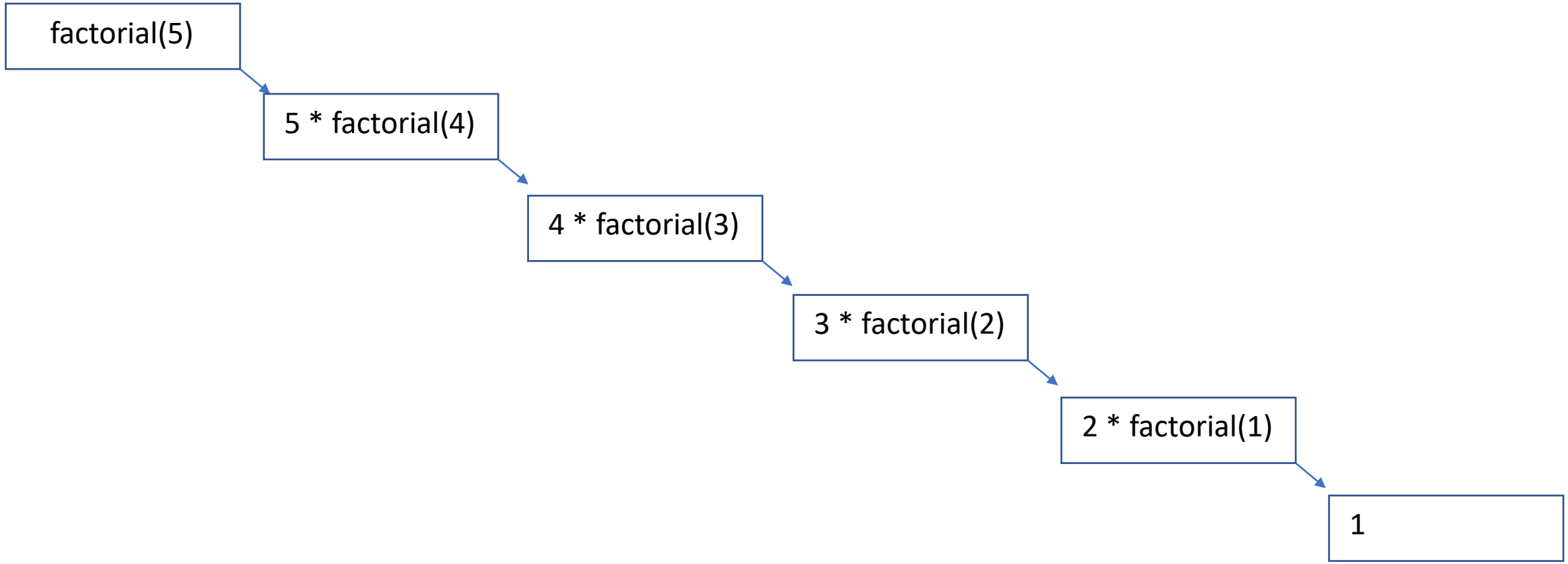
Factorial



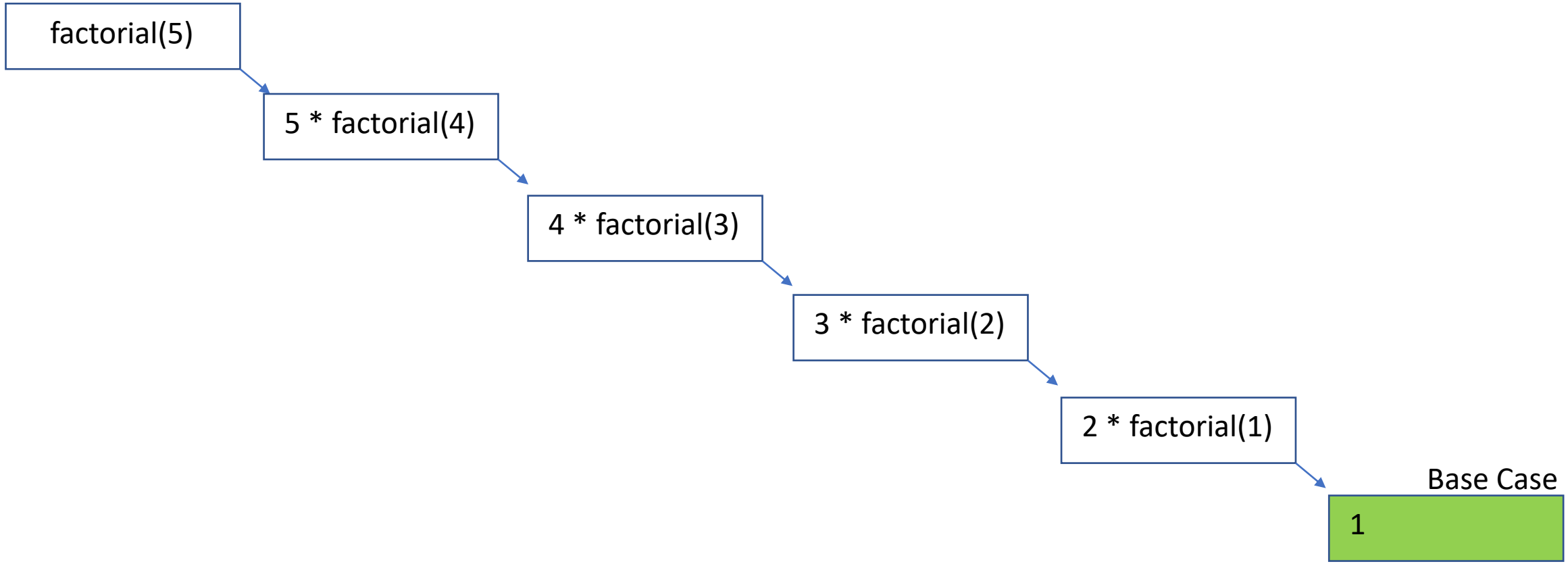
Factorial


factorial(5)
5 * factorial(4)
4 * factorial(3)
3 * factorial(2)
2 * factorial(1)

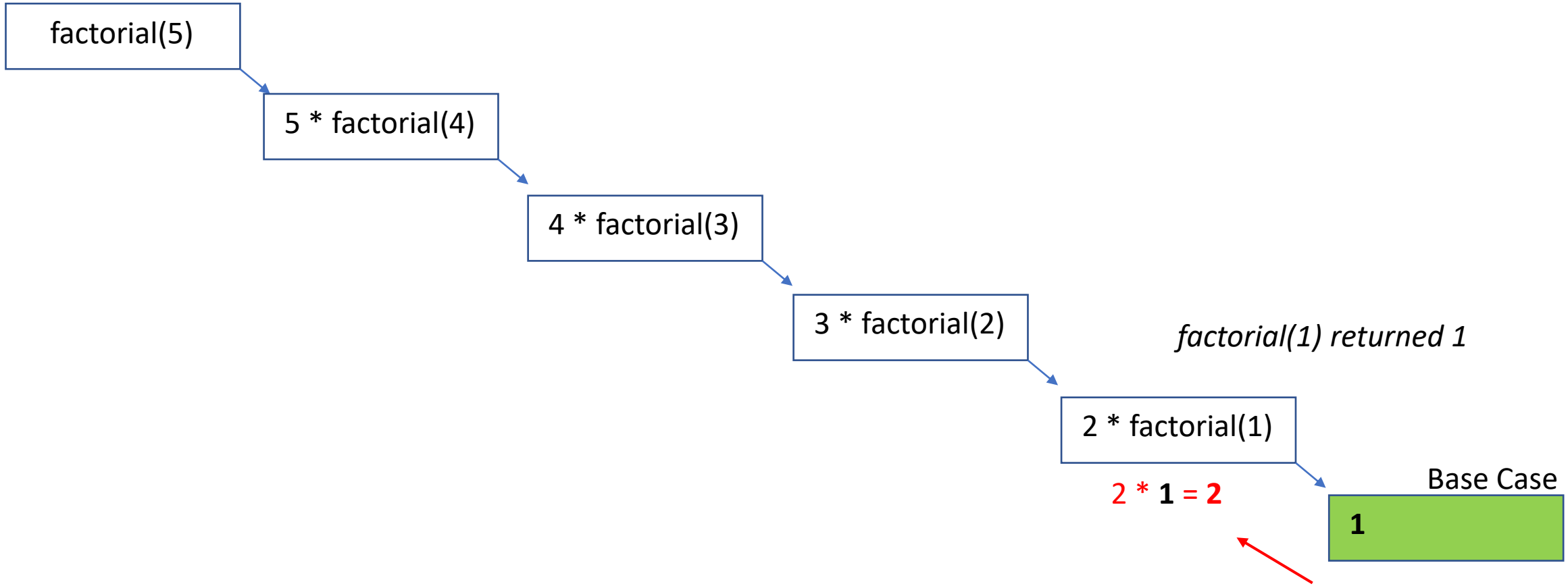
Factorial


factorial(5)
5 * factorial(4)
4 * factorial(3)
3 * factorial(2)
2 * factorial(1)
1

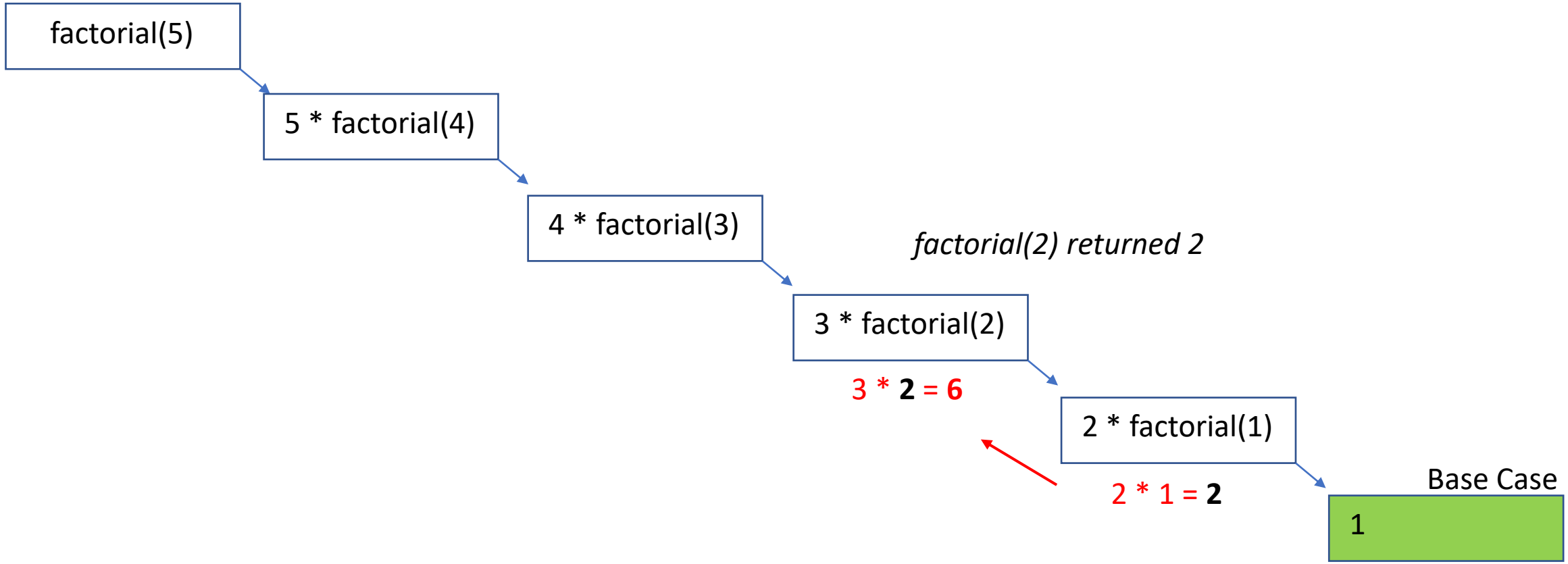
Factorial


factorial(5)
5 * factorial(4)
4 * factorial(3)
3 * factorial(2)
2 * factorial(1)
Base Case
1

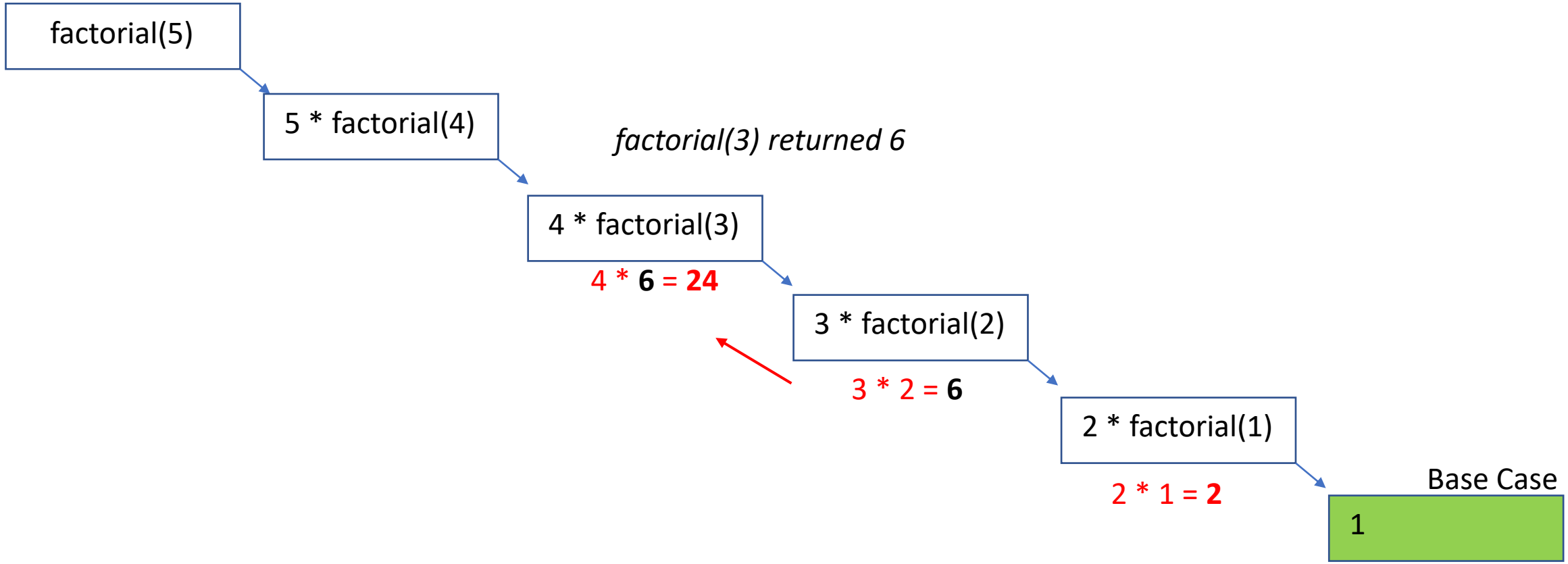
Factorial


factorial(5)
5 * factorial(4)
4 * factorial(3)
3 * factorial(2)
factorial(1) returned 1
2 * factorial(1)
2 * 1 = 2
Base Case
1

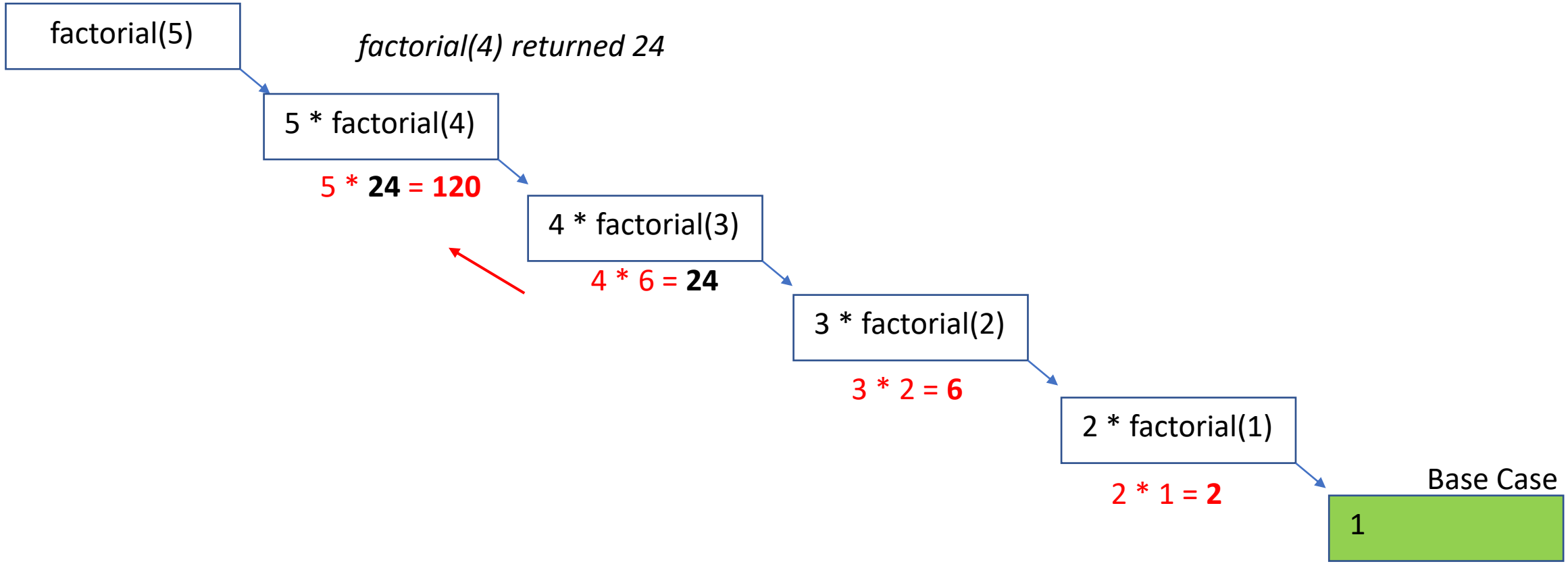
Factorial


factorial(5)
5 * factorial(4)
4 * factorial(3)
factorial(2) returned 2
3 * factorial(2)
3 * 2 = 6
2 * factorial(1)
2 * 1 = 2
Base Case
1

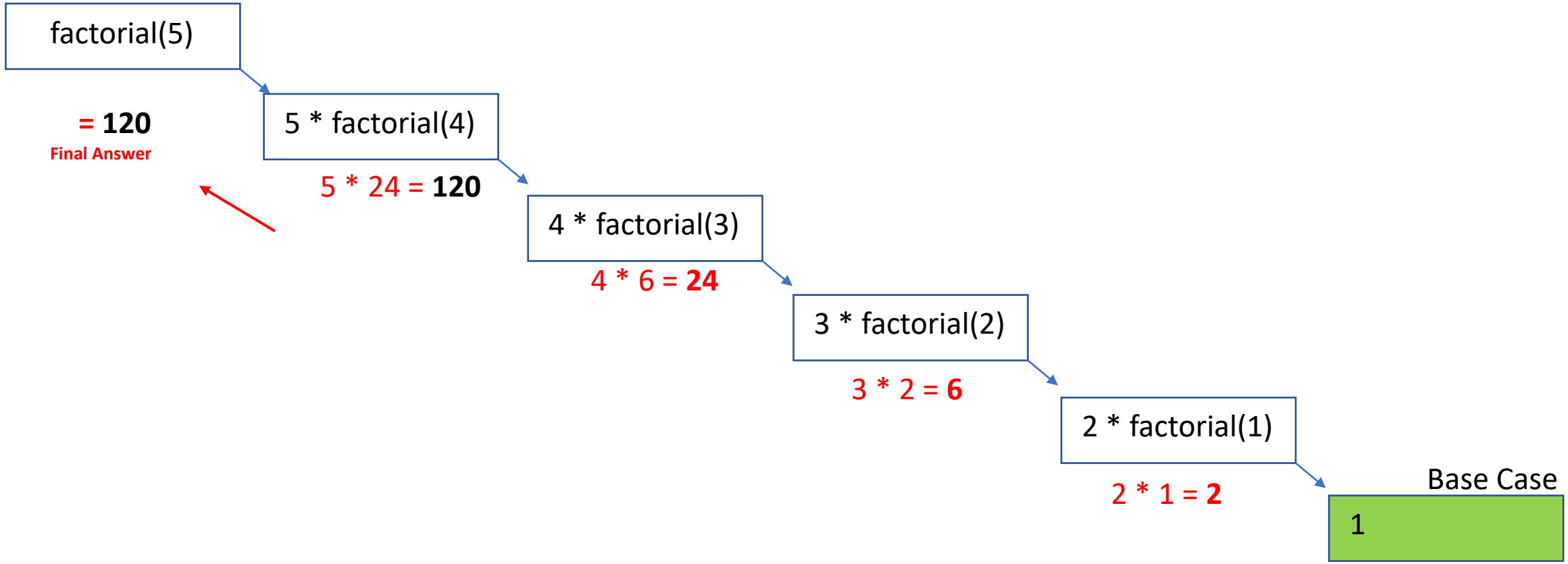
Factorial


factorial(5)
5 * factorial(4)
factorial(3) returned 6
4 * factorial(3)
4 * 6 = 24
3 * factorial(2)
3 * 2 = 6
2 * factorial(1)
2 * 1 = 2
Base Case
1

Factorial


factorial(5)
factorial(4) returned 24
5 * factorial(4)
5 * 24 = 120
4 * factorial(3)
4 * 6 = 24
3 * factorial(2)
3 * 2 = 6
2 * factorial(1)
2 * 1 = 2
Base Case
1

Factorial


factorial(5)
= 120
Final Answer
5 * factorial(4)
5 * 24 = 120
4 * factorial(3)
4 * 6 = 24
3 * factorial(2)
3 * 2 = 6
2 * factorial(1)
2 * 1 = 2
Base Case
1

Recursion Example

Write a recursive program that will count the number of **P**'s in a string

Write a recursive function that will return True if a string is a palindrome

Recursive Palindrome Strategy

What is the smallest sub-problem that where will *always* have an answer?

Recursive Palindrome Strategy

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Fact:
If a string has a size of 1, it is a palindrome

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if(len(word) == 1 or len(word) ==  0):
    return True
```

Recursive Palindrome Strategy

What is the smallest sub-problem that where will *always* have an answer?

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```
if(len(word) == 1 or len(word) ==  0):
    return True
```

How can we recursively make this problem smaller to get to our base case?

Recursive Palindrome Strategy

What is the smallest sub-problem that where will *always* have an answer?

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Fact:
If a string has a size of 0, it is a palindrome

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if(len(word) == 1 or len(word) ==  0):
    return True
```

Let's check the first and last character of the string.

Recursive Palindrome Strategy

What is the smallest sub-problem that where will *always* have an answer?

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If a string has a size of 1, it is a palindrome

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If a string has a size of 0, it is a palindrome

```
if(len(word) == 1 or len(word) ==  0):
    return True
```

Let's check the first and last character of the string.

If the are not equal, then we do not have a palindrome

```
elif(word[0] != word[-1]):
    return False
```

Recursive Palindrome Strategy

What is the smallest sub-problem that where will *always* have an answer?

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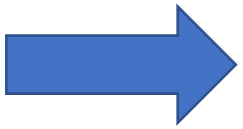

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elif(word[0] != word[-1]):
    return False
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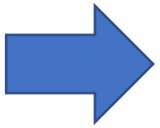
Otherwise, lets remove the first and last character of string and pass the new string into our function (recursion)



```
else:
    return is_palindrome(word[1:-1])
```

Recursive Palindrome Strategy

"aabccbaa"

What is the smallest sub-problem that where will *always* have an answer?

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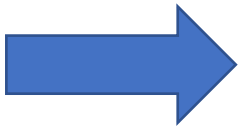

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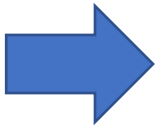

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Recursive Palindrome Strategy

"aabccbaa"
"abccba"

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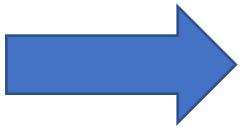

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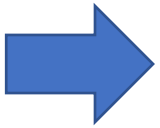

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else:
    return is_palindrome(word[1:-1])
```

Recursive Palindrome Strategy

“aabccbaa”
“abccba”
“bccb”

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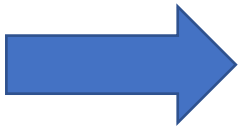

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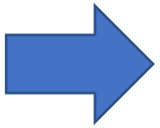

```
else:
    return is_palindrome(word[1:-1])
```

Recursive Palindrome Strategy

“aabccbaa”
“abccba”
“bccb”
“cc”

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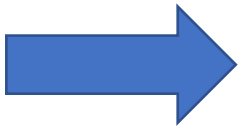

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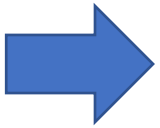

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Recursive Palindrome Strategy

What is the smallest sub-problem that where will *always* have an answer?

"aabccbaa"
"abccba"
"bccb"
"cc"
"" ← Base case reached!

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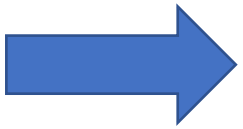

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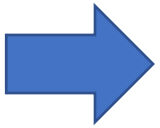

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else:
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```

Recursion Example

is_palindrome(“racecar”)

```
def is_palindrome(word):

    if len(word) == 1 or len(word) == 0:
        return True
    elif word[0] != word[-1]:
        return False
    else:
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Recursion Example

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Recursion Example

is_palindrome(“racecar”)

is_palindrome(“aceca”)

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    if len(word) == 1 or len(word) == 0:
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Recursion Example

is_palindrome(“racecar”)

is_palindrome(“aceca”)

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def is_palindrome(word):

    if len(word) == 1 or len(word) == 0:
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        return False
    else:
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```

Recursion Example

is_palindrome(“racecar”)

is_palindrome(“**a**ceca**a**”)

```
def is_palindrome(word):

    if len(word) == 1 or len(word) == 0:
        return True
    elif word[0] != word[-1]:
        return False
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```

Recursion Example

is_palindrome(“racecar”)

is_palindrome(“aceca”)

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Recursion Example

is_palindrome(“racecar”)

is_palindrome(“aceca”)

is_palindrome(“cec”)

```
def is_palindrome(word):

    if len(word) == 1 or len(word) == 0:
        return True
    elif word[0] != word[-1]:
        return False
    else:
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```

Recursion Example

is_palindrome(“racecar”)

is_palindrome(“aceca”)

is_palindrome(“cec”)

```
def is_palindrome(word):

    if len(word) == 1 or len(word) == 0:
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    elif word[0] != word[-1]:
        return False
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Recursion Example

is_palindrome(“racecar”)

is_palindrome(“aceca”)

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def is_palindrome(word):

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Recursion Example

is_palindrome(“racecar”)

is_palindrome(“aceca”)

is_palindrome(“cec”)

is_palindrome(“e”)

```
def is_palindrome(word):

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Recursion Example

is_palindrome(“racecar”)

is_palindrome(“aceca”)

is_palindrome(“cec”)

is_palindrome(“e”)

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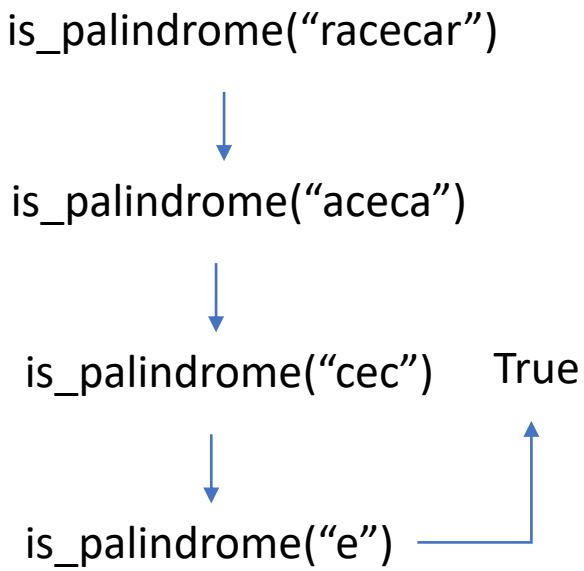
Recursion Example



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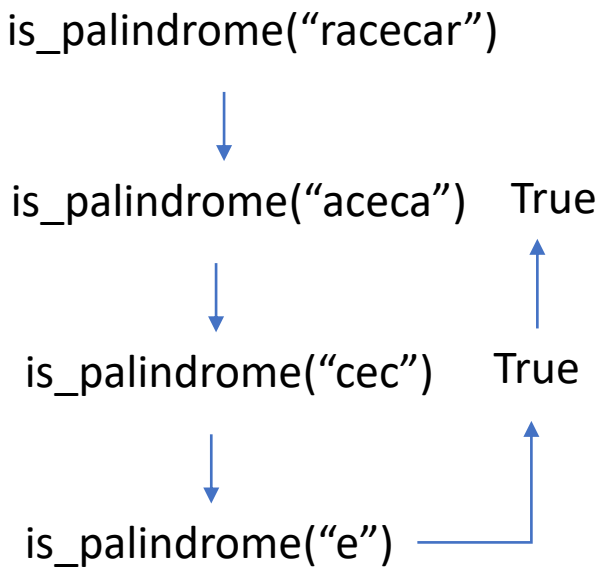

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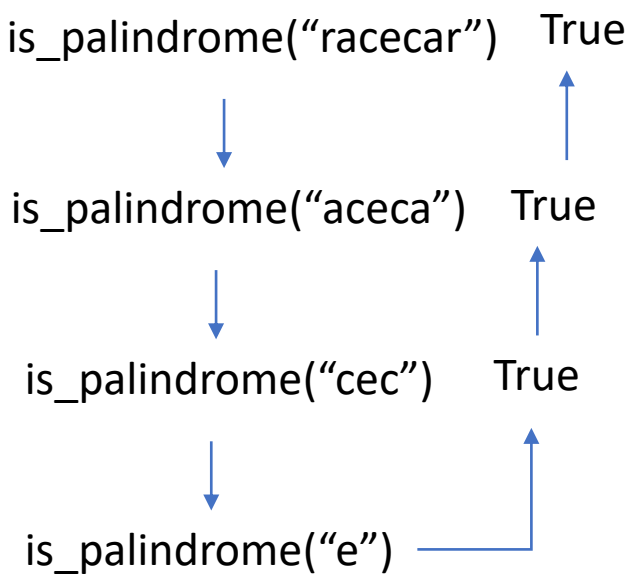

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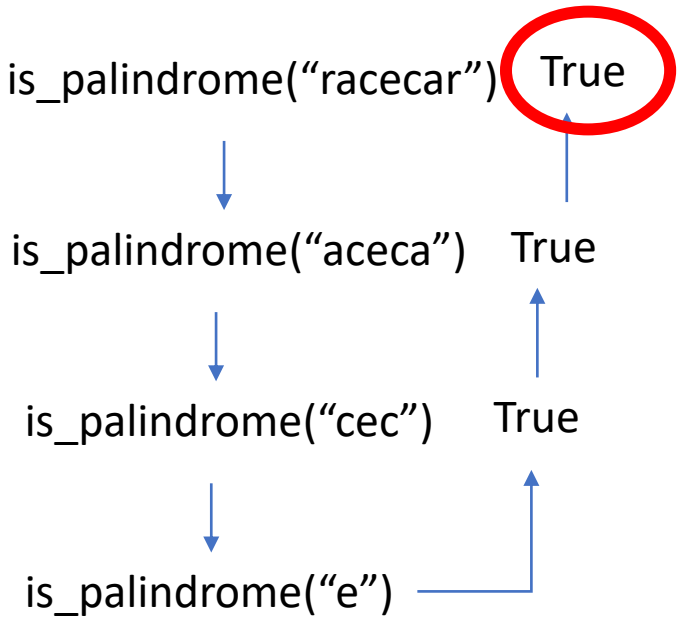

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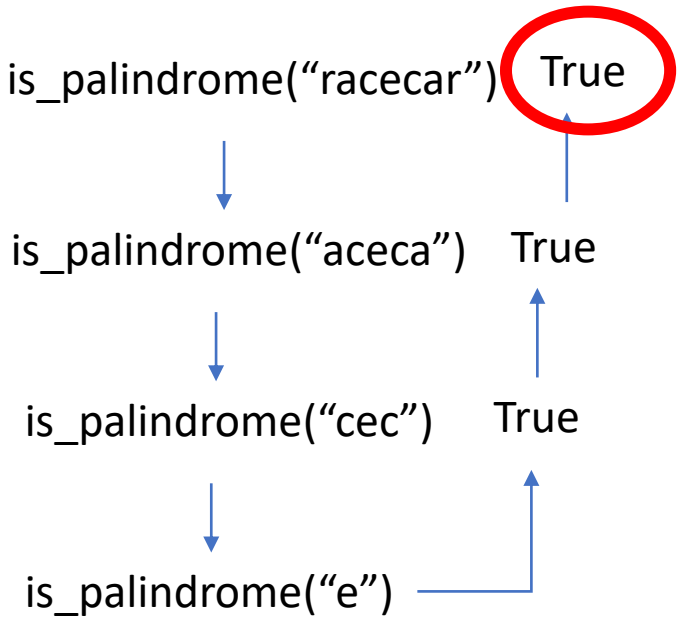

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