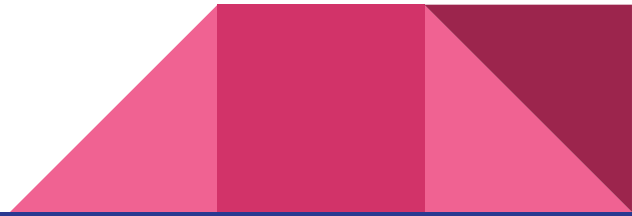
#CodeYork

Session 3: Recursion and Examples

Recap

- Last time, we looked at:
  - Defining functions
  - Calling functions
  - For loops
  - The range function
  - While loops

Questions? Speak up now!



Part 1: Introduction to Recursion

Recursion

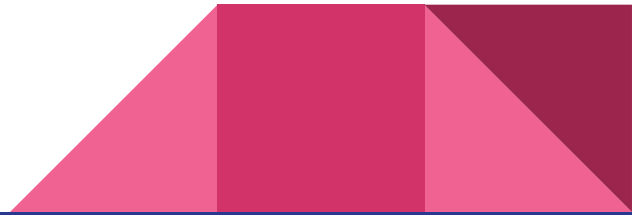
We can define how to solve both the simplest case and how to reduce the difficulty of solving a problem, bit by bit

What’s Recursion?

- Recursion is defining a solution in terms of itself
  - Our problem needs to have some cases where the solution is immediately obvious, and others where the problem can be simplified to a smaller one
  - Keep simplifying our problem again and again until we get a case with an obvious solution
- The simple cases (base cases)
- The other cases, where the problem must be simplified (recursive cases)

Factorials

- The factorial function is: n! = n * (n - 1) * … * 2 * 1
- Some examples are:
  - 1! = 1
  - 2! = 1 * 2 = 2
  - 3! = 1 * 2 * 3 = 6
  - 10! = 10 * 9 * 8 * 7 * 6 * 5 * 4 * 3 * 2 * 1 = 3628800
- This can be expressed recursively (see exercises)



Palindromes

- A palindrome is a word, phrase, number, or other sequence of characters which reads the same backward or forward.
  - eg. “madam” or “kayak”
- There are two ways to check if a string is a palindrome:
  - Directly from the definition, we can just reverse the string, and then check if it’s equal
  - We can use recursion to check if the first and last character are the same, and then, check the if middle part is a palindrome, recursively (see exercises)

Course Website

Remember, all the slides and exercises are available at:

https://york.gjcampbell.co.uk/

Factorials Task Solution

```
def factorial(n):
    if n == 1:
        return 1
    else:
        return n * factorial(n - 1)

print(factorial(4))
```

Base Case

Recursive Case

Palindromes Task Solution

```
def is_palindrome(word):
    if len(word) < 2:
        return True
    elif word[0] == word[-1]:
        return is_palindrome(word[1:-1])
    else:
        return False

print(is_palindrome('hannah'))
```

Base Case 1

Recursive Case

Base Case 2

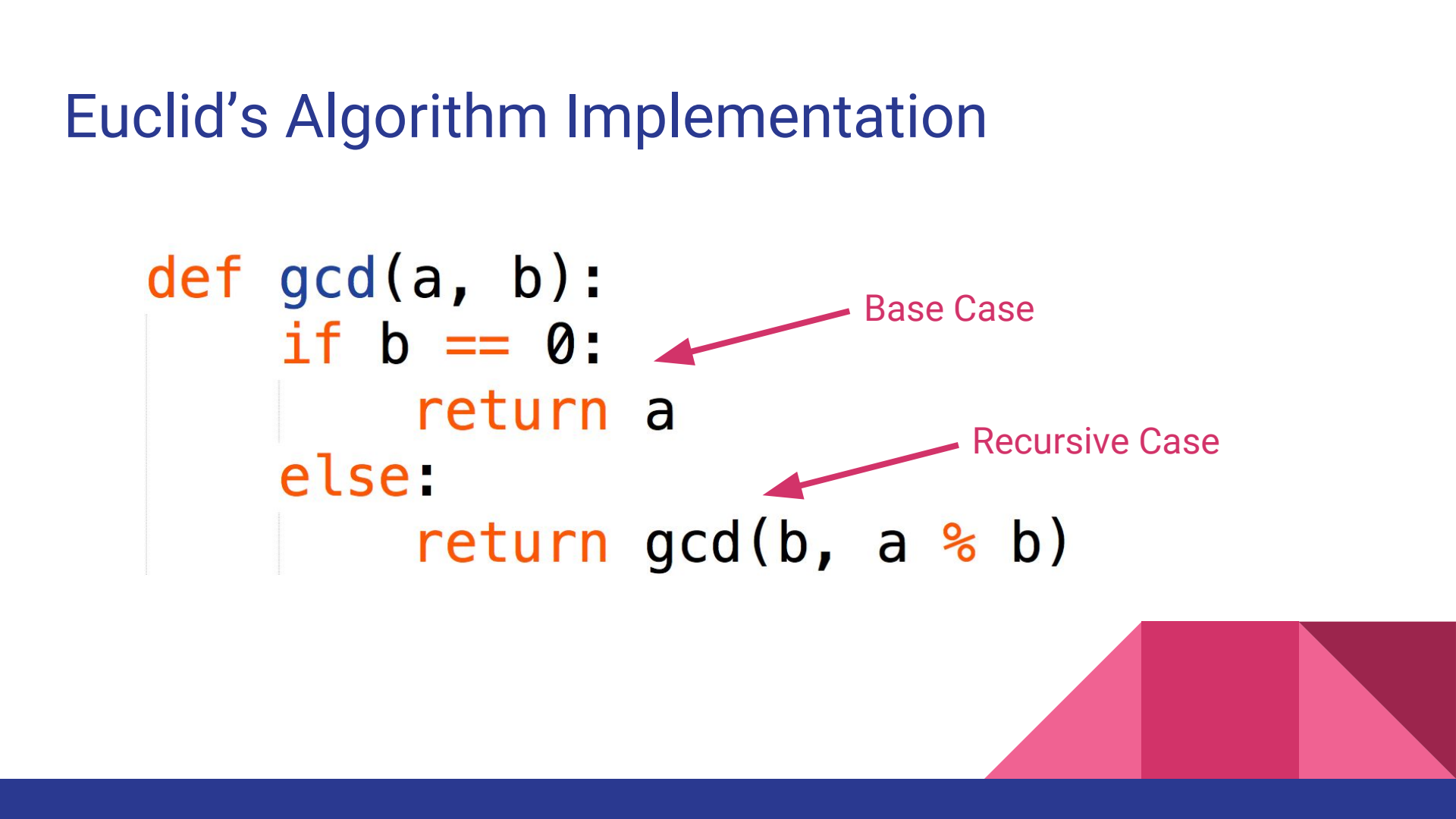
Part 2: Interesting Examples

Intro to Euclid’s Algorithm

- The GCD of two integers is their greatest common divisor/factor (HCF)
- For example:
  - gcd(2, 3) = 1
  - gcd(4, 6) = 2
  - gcd(21, 18) = 3
- The Euclidean Algorithm finds the GCD of two integers
- This is an example of a recursive algorithm

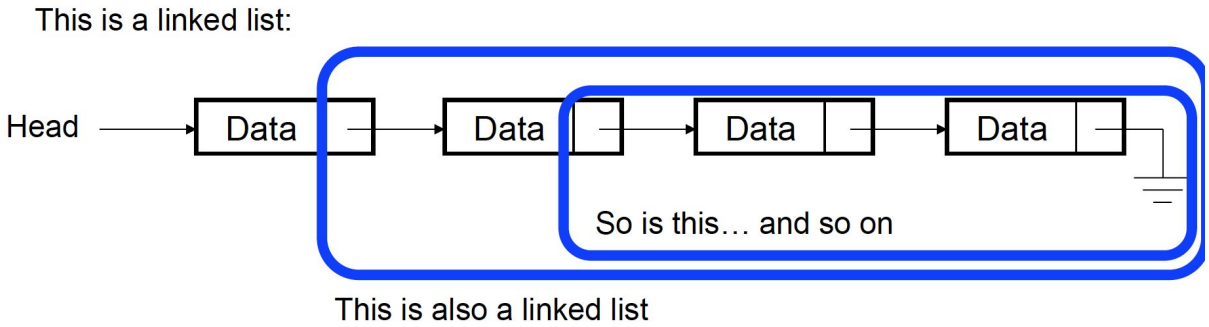
Euclid’s Algorithm Implementation

```
def gcd(a, b):
    if b == 0:
        return a
    else:
        return gcd(b, a % b)
```



Recursive Data Structures

- Just like algorithms, we can define data structures recursively.
- A linked list is an example of such a data structure.
  - Base case: The linked list is nothing, eg. *None* in Python.
  - Recursive case: The linked list has two items: the first element and the rest of the list.



Interpreters and Compilers

- Interpreters and compilers are programs that take programs as input!
- Interpreters then run these input programs, if they are valid, and if not they may give us information about why they are invalid, so we can fix them
  - You have seen this with the Python interpreter when using IDLE
- Compilers also take programs as input, but they output programs
  - Programs may be in the same language, but more commonly, are in some lower level language, such as assembly code for a CPU
- Interpreters and compilers use recursion!

“To understand recursion, one must first understand recursion.”

- Stephen Hawking

Summary

- Today, we have looked at:
  - Recursive definitions
  - Factorials
  - Palindromes
  - GCD and Euclid's Algorithm
  - Recursive Data Structures
  - Interpreters and Compilers

} Don't worry about this stuff!
Really just for interest's sake!

Questions? Speak up now!

Thanks!

Contact us:

gjc510@york.ac.uk
jr1161@york.ac.uk

https://york.gjcampbell.co.uk/