

National University of Singapore  
School of Computing  
CS1010X: Programming Methodology  
Semester II, 2022/2023

**Mission 2 - Side Quest**  
**Magic Efficiency**

Release date: 30 January 2023

**Due: 23 February 2023, 23:59**

## Required Files

- sidequest02.4-template.py

This side quest consists of **three** tasks.

## Task 1: Simplification (4 marks)

Give the simplified big-O notations for all eight expressions below. Determine in each group which one has the faster-growing order of growth. (Note: you may express  $x^y$  in the format  $x^y$ )

- (i)  $O(4^n n^2)$  vs  $O(n 3^n)$
- (ii)  $O(10000000000 n^2)$  vs  $O(2^n / 10000000000)$
- (iii)  $O(n^n + n^2 + 1)$  vs  $O(4^n + 2^n)$
- (iv)  $O(1^n)$  vs  $O(n^2)$

## Task 2: Analysis (2 marks)

Consider the following function foo:

```
def foo(n):  
    def bar(n):  
        if n == 0:  
            return 0  
        else:  
            return 1 + bar(n - 1)  
    return n * bar(n)
```

What is the time complexity for the running time of foo in terms of its input  $n$ ? What about space complexity?

### Task 3: Improvisation (6 marks)

Consider the following two functions:

```
def bar(n):  
    if n == 0:  
        return 0  
    else:  
        return n + bar(n - 1)  
  
def foo(n):  
    if n == 0:  
        return 0  
    else:  
        return bar(n) + foo(n - 1)
```

- (i) What is the time complexity of bar? What about foo?
- (ii) What is the space complexity of bar? What about foo?
- (iii) Implement improved\_foo **using any method** such that it computes the same value as foo, but with improved efficiency. To get full credit, your new function must have improved (slower-growing) order of growth in both time **and** space. Be sure that your function returns an int!
- (iv) State the order of growths for your improved\_foo clearly in order notations.