

Computational Management Science 1

Fall 2019 Final

registration number: SAMPLE SOLUTION

(Do not write your name on the test - just the 7 digit student id number.)

All examples are evaluated using the Python programming language, version 3.6.

1. (6 points) Writing Code

(a) (3 points, ≤ 5 minutes) Functions

The Fibonacci numbers F_n are defined as follows: $F_0 = 0$, $F_1 = 1$, and $F_n = F_{n-2} + F_{n-1}$ for all $n \geq 2$. I.e. we get the following sequence 0, 1, 1, 2, 3, 5, 8, ... Write a function `fibonacci(n)`, which returns the n th Fibonacci number. Add a proper docstring to receive full points.

```
def fibonacci(n):
    """
    Computes the nth Fibonacci numbers.

    Arguments:
    n -- Fibonacci number index

    >>> fibonacci(6)
    8
    """
    if n == 0:
        return 0

    elif n == 1:
        return 1

    else:
        return fibonacci(n - 2) + fibonacci(n - 1)
```

(b) (3 points, ≤ 5 minutes) Classes and data structures

Implement a simple data structure in Python. The data structure must be capable of storing a triangle in a two dimensional drawing application (e.g. the coordinates of three points). Write a **minimalistic** class (`__init__(.)`). You don't need to implement any functionality, just a class that stores the required data. Note that your implementation must be self-contained and must not rely on any third party functionality not provided by you. Don't forget to write docstrings in order to receive full points.

```
class Triangle:
    """A triangle in a two-dimensional Euclidean plane."""

    def __init__(self, a_x: float, a_y: float,
                 b_x: float, b_y: float,
                 c_x: float, c_y: float):
        self.a_x = a_x
        self.a_y = a_y
        self.b_x = b_x
        self.b_y = b_y
        self.c_x = c_x
        self.c_y = c_y
```

2. (6 points, ≤10 minutes) Correct Mistakes

The following code contains 12 syntax errors/typos. Clearly mark and correct the mistakes. The code must run self-contained (that is without any import statements that are not included). The output should be:

The person "name: Genius, age: 22" is an adult.

```
import sys

class Person:
    '''Class containing the name and the age of one person.'''

    def __init__(self, name, age):
        self.name = name
        self.age = age

    def __str__(self):
        return (f'name: {self.name}, '
                f'age: {self.age}')

def main():
    me = Person('Genius', 22)
    if 18 <= me.age <= 65:
        print(f'The person "{me}" is an adult.')
    return 0

if __name__ == '__main__':
    sys.exit(main())
```

3. (9 points, ≤10 minutes) Libraries

(a) (2 points)

What is the purpose of profiling? Which library helps with doing so?

Profiling means analyzing a program in terms of memory consumption and runtime. Python offers the `cProfile` library to help with profiling Python programs.

(b) (2 points)

What is an `ndarray`? Which 3rd party package provides them?

`ndarray` is an n-dimensional array. It is a part of the `numpy` library.

(c) (3 points)

What is the purpose of unit tests? What is the purpose doctests? Is it sufficient to have one or the other? If you need both, which test cases should be covered by unit tests and which ones by doctests?

Each unit test should answer a specific question about a distinct code unit. The code is tested without depending on any other code via mocking. Doctests are used to demonstrate (document) how the code should be used. Both are necessary - unittests focus on testing the code quality, doctests are documentation that can be tested for correctness. Unittests should cover all edge cases and some common cases, doctests should demonstrate how the code is to be used with a common, easy to understand example.

(d) Finally, name one thing you like about this course and one thing that should be improved in the future (be honest!) (2p).

UP TO THE STUDENTS...

4. (12 points, ≤10 minutes) Reading and Understanding Code

What is the output of the following code snippets? Write exactly what the output of each snippet is if the snippet is the sole content of a Python file. If the output is an error message, it is enough to write "ERROR". If there is no output, write "-"

(a) Simple calculation

```
x = 5
y = 3 * x**2 + 2 * x - 7
print(y)
```

78

(b) Loop

```
p = 13
result = True
for i in range(2, p):
    if p % i == 0:
        result = False
        break
```

```
print(result)
```

True

(c) Function

```
def swap(a, b):
    c = a
    a = b
    b = c
    return a, b
```

```
a = 5
b = 10
c, d = swap(a, b)
print(a, b, c, d)
```

5 10 10 5

(d) Lists and tuples

```
values = (-5, 4, 3)
values[0] = 5
```

ERROR

(e) String operations

```
s = "Everyone wants to get the grade 1 in CMS."  
print(s.find("Everyone"))  
print(s[2])
```

```
0  
e
```

(f) List comprehension

```
integers = [i for i in range(10)]  
print(sum(integers))
```

```
45
```

5. (9 points, ≤10 minutes) Various

(a) (3 points)

What is a generator expression (PEP 289)? Which key advantage does it have? Provide at least one example.

A high performance, memory efficient generalization of list comprehensions.

```
sum(x*x for x in range(10))
```

(b) (3 points)

What is inheritance? What is composition? Which relationship types does each of them model?

In object-oriented programming, inheritance is the mechanism of basing a class upon another class.

Object composition is a way to combine objects or data types into more complex ones.

Aggregation is very similar but does not imply ownership.

Inheritance models an “is-a” relationship while composition and aggregation model a “has-a” relationship.

(c) (3 points)

When passing a list to a function, can the list be changed? Why was that implementation decision taken (what are the advantages)? What could you do to avoid that behavior?

Yes, the list can be changed since Python passes a reference to the list object. This has performance and memory benefits since Python does not have to create a copy of each list. If you want to ensure immutability, pass a tuple instead of a list... but watch out for nested objects which could still be changed.

6. (6 points, ≤5 minutes) Writing Files

In one of your Python programs, the central results are stored in a special object which cannot easily be represented as text. Your employer asks you to design and implement a function that stores that object permanently. Explain how you approach the problem and why you decide to do so. Implement the function

`save(filename: str, result_object) -> None` that takes a filename string and the resulting object. The function should write the object to a file with the given name. Any representation of the data is ok as long as it allows to easily read the data back in from the file (but you don't need to implement the reading function, just the writing function). Don't forget to document the function in order to receive full points.

I would approach a solution as simple as possible. Since it doesn't seem to be easy to serialize the object as text, I would use Python's built-in `pickle` module. This also allow easy reading of that object.

```
import pickle

def save(filename: str, object) -> None:
    """Save the given results to a binary file."""
    with open(filename, 'wb') as f:
        pickle.dump(object, f)
```