National University of Singapore
School of Computing
CS1010S: Programming Methodology
Semester II, 2022/2023

Tutorial 2
Functional Abstraction, Recursion & Iteration

1. Define a function `magnitude` that takes in the coordinates of two points on a plane, `(x1, y1)` and `(x2, y2)`, as arguments and returns the magnitude of the vector between them.

```
def magnitude(x1, y1, x2, y2):
    # Returns the magnitude of the vector
    # between the points (x1, y1) and (x2, y2).

>>> magnitude(2, 2, 5, 6)
5.0
```

2. A function can be viewed as a black box. All you need to know are the arguments it takes as input and what its output is.

   (a) One way of calculating the area of a triangle is using the formula $area = \frac{1}{2} \times base \times height$.

   Define a function `area` that calculates and returns the area of any given triangle using this formula.

   Decide what arguments it requires as input and what its return value should be.

```
def area(<your arguments>):
    # Return area of the triangle using the formula
    # area = 1/2 * base * height.
```

   (b) Another way of calculating the area of a triangle with sides `A`, `B`, `C` is using the trigonometric ratio sine to get $area = \frac{1}{2} \times A \times B \times sin(AB)$, where `AB` is the included angle between sides `A` and `B`.

   The `sin` function is provided by the `math` package. You can call it by using `sin` after including the line `from math import *` at the top of your Python file. For information on how to use the `math` package, refer to
   `https://docs.python.org/3.10/library/math.html`

   Define a function `area2` that calculates and returns the area of any given triangle using this formula.

   Decide what arguments the function requires as input and what its return value should be.

```
def area2(<your arguments>):
    # Return area of the triangle using the formula:
    # area = 1/2 * A * B * sin(AB).
```

   (c) Both functions calculate the same result. Can they be directly substituted for each other? Why?

(d) We can also calculate the area of triangle using Heron's Formula, $area = \sqrt{s(s-a)(s-b)(s-c)}$ where $s = \frac{a+b+c}{2}$. Assume you are given a function `herons_formula` that takes 3 arguments `a, b, c` and returns the area of a triangle with sides of length `a, b, c`.

Define a function area3 that uses Heron's formula to calculate and return the area of a given triangle given the x,y coordinates of the 3 points of the triangle.

You may use the `magnitude` function defined in Question 1

```
def area3(x1, y1, x2, y2, x3, y3):
    # Return area of the triangle using Heron's formula.
```

3. For each of the questions below, what is printed when the expressions are evaluated?

(a)
```
def foo1():
    i = 0
    result = 0
    while i < 10:
        result += i
        i += 1
    return result
print(foo1())
```

(b)
```
def foo2():
    i = 0
    result = 0
    while i < 10:
        if i == 3:
            break
        result += i
        i += 1
    return result
print(foo2())
```

(c)
```
def bar1():
    result = 0
    for i in range(10):
        result += i
    return result
print(bar1())
```

(d)
```
def bar2():
    result = 0
    for i in range(10):
        if i % 3 == 1:
            continue
        result += i
    return result
print(bar2())
```

4. Write a function `sum_even_factorials` that finds the sum of the factorials of the even numbers that are less than or equal to `n`, where `n` ≥ 0.

```
>>> sum_even_factorials(1)
1

>>> sum_even_factorials(3)
3

>>> sum_even_factorials(6)
747
```

5. Suppose we define the function:

```
def f(g):
    return g(2)
```

Then we have

```
def square(x):
    return x ** 2

>>> f(square)
4

>>> f(lambda z: z * (z + 1))
6
```

What happens if we (perversely) ask the interpreter to evaluate the combination `f(f)`? Explain.