Introduction to Programming and Computer Science

Assignment 2: Input, Output, Expressions, and Variables

Due: Tuesday, September 19, 2018 by 10:00pm

Worth 100 points

This programming homework is designed to get you more practice with reading values from the keyboard, using expressions to process these value, and writing functions.

1 Population Explosion

When scientists talk about half-life, they are referring to how long it will take for half of a sample to decay. In the case of nuclear waste, it refers to how long it takes for half of the radioactive material to turn into lead.

Exponential growth is very similar, but deals with, you guessed it, growth, instead of decay. The most common example is the growth of bacteria colonies. Bacteria multiply at an alarming rate. If we assume that bacteria can double every hour and if we start with just a single bacteria, then after one day there will be over 16 million bacteria!

Obviously exponential growth, or decay for that matter, cannot continue indefinitely. Eventually there would no longer be any space or nutrients available for the bacteria, or the last atom of plutonium would decay into lead. As a result, exponential growth and decay only refers to the early stages of both processes.

The mathematics behind exponential growth and decay is rather simple. In fact, we use the same formula as for continuous compound interest. Source (http://math.ucsd.edu/ wgar- ner/math4c/textbook/chapter4/expgrowthdecay.htm)

$N = N_0e^{kt}$

where N is the final population, N_0 is the starting population, k is growth rate and t is time. For example, if current population of a species is 1000, growth rate is 0.02 and we want to know the population after 1 day , the above equation will give us:

$N = 1000 * e^{0.02*24} = 1616.07440219$

Task 1 (10 pts) Write a function called populationEstimation that takes the initial population, growth rate, and time as parameters and returns the population at the end of the time given. For Example:

```
populationEstimation(1000,0.02,24) returns 1616
populationEstimation(1000,0.02,13) returns 1296
populationEstimation(1000,-0.02,13) returns 771
populationEstimation(1000,-0.02,300) returns 2
```

2 Party by the pool

Pool balls are arranged in rows where the first row contains 1 pool ball and each row contains 1 more pool ball than the previous row. Thus, if there are 3 rows, then we'd have 6 total pool balls (1+2+3).

Task 2 (10 pts) Write a function called poolBalls that takes the number of rows as parameter and returns the number of pool balls in that number of rows. For Example:

```
poolBalls(0) returns 0
poolBalls(1) returns 1
poolBalls(4) returns 10
```

3 Digitization

Task 3 (15 pts) Write a function called setKthDigit, that takes three integers parameters: an integer n, and integer k and an integer d - where n is strictly positive, k is non-negative, and d is a digit between 0 and 9. Your function should return the number n but with the kth digit replaced with d. Counting starts at 0 and goes right-to-left, so the 0th digit is the rightmost digit. **You are not allowed to use loops or conditional execution (if statements) in this question. You cannot convert a number to a string either.** For example:

```
setKthDigit(468, 0, 1) returns 461
setKthDigit(468, 1, 1) returns 418
setKthDigit(468, 2, 1) returns 168
setKthDigit(468, 3, 1) returns 1468
setKthDigit(468, 4, 1) returns 10468
```

If your function is able to handle negative number, you get 10 point extra credit. For example:

```
setKthDigit(468, 0, 1) returns 461
setKthDigit(-468, 0, 1) returns -461
setKthDigit(-468, 2, 1) returns -168
setKthDigit(-468, 3, 1) returns -1468
setKthDigit(-468, 4, 1) returns -10468
```

4 Big and small Triangles

Task 4 (10 pts) In this problem, we will write functions that enable us to find the area of triangle when the coordinates of the thee corners of the triangles are given. The first function you will write should be called distance. This function takes x and y coordinates of two points and return the euclidean distance between these points. For example:

```
distance(0, 0, 0,0) returns 0.0
distance(0, 0, 3,4) returns 5.0
distance(1, 1, 5,8) returns 8.0622577483
distance(-5, 1, 6,-3) returns 12.0830459736
```

Task 5 (15 pts) The second function you will write is called triangleAreaFromSides that takes the three sides of the triangle as parameters and returns the area of the triangle. For Example:

```
triangleAreaFromSides(0, 0, 0) returns 0.0
triangleAreaFromSides(2, 2, 3) returns 1.9843134833
triangleAreaFromSides(3, 4, 5) returns 6.0
triangleAreaFromSides(8, 9, 15) returns 29.9332590942
```

Task 6 (15 pts) The third function should use the first two functions to calculate the area of a triangle using the coordinates of the three corners. The function should be called triangleAreaByCoordinates and should take six parameters. For Example:

```
triangleAreaByCoordinates(0, 0, 3, 4, 5,5) returns 2.5
triangleAreaByCoordinates(5, 6, 2, 3, -1, 2) returns
3.0
triangleAreaByCoordinates(-1,-2,-3,-2,0,0) returns 2.0
triangleAreaByCoordinates(-5, 1, 6,-3,2,80) returns
448.5
```

5 Going to the Taylor

We studied the constant e (The Euler's Number) in school and were made to memorize its value - 2.7182. You might have heard of the exponential function with is normally written as e^X. The cool thing about e^X is that if you differentiate e^X you get e^X back. One simple way of estimating this functions is to use something called Taylor series. Without going into the details of how and why this series works, the following equations are used for estimating the value of e^X for any value of x.

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + ...$$

Now if you differentiate the above expression you get:

$$0 + 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + ...$$

which is the same as the original series, and like I said, is pretty cool. Similarly, there are several other functions that have their equivalent Taylor series expansion. The Taylor series for natural log ln(1 + x) is given below:

$$ln(1 + x) = x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4} + \frac{x^5}{5} for|x| <= 1$$

Task 7 (25 pts) For this task, you will write two functions. First, write a Function called eulerPower, that takes the value for x as a parameter and then returns the value of function e^X using the appropriate Taylor series given above. Although this series consists of infinite terms, you will only use the first 5 terms as shown in the equations above.. For Example:

- eulerPower(0.5) returns 1.6484375

Second, write a Function called natLog, that takes the value for x as a parameter and then returns the value of function ln(1 + x), using the appropriate Taylor series given above. Although this series consists of infinite terms, you will only use the rst 5 terms as shown in the equations above. For Example:

- natLog(1.5) should return 0.407291666667