Section, Name and ID#:

AMERICAN UNIVERSITY OF ARMENIA

College of Science and Engineering

CS 120 Introduction to Object-Oriented Programming

MIDTERM EXAM

13

Date / Time: Friday, March 17 2017 at 17:30

Duration: 2 hours

Attention: **ANY TYPE OF COMMUNICATION IS STRICTLY PROHIBITED**

Write down your section, name and ID# at the top of all used pages

Participation:

Problem 1: Consider below a C++ function ***float kahan(float num1, float num2, float& compensation)*** that implements the ***Kahan Summation Algorithm*** for high-precision compensated summation of two float arguments ***float num1*** and ***float num2***:

```
float kahan(float num1, float num2, float &compensation)
{
        float result;
        num2 -= compensation;
        result = num1 + num2;
        compensation = (result - num1) - num2;
        return result;
}
```

Using this function, write a C++ function ***float pi(int n)*** that computes the value π by the following formula:

$$\pi = 16\sum_{k=0}^{n}\frac{(-1)^k}{(2k+1)5^{2k+1}} - 4\sum_{k=0}^{n}\frac{(-1)^k}{(2k+1)239^{2k+1}} = \left(\frac{16}{1*5}-\frac{4}{1*239}\right)-\left(\frac{16}{3*5^3}-\frac{4}{3*239^3}\right)+\left(\frac{16}{5*5^5}-\frac{4}{5*239^5}\right)-\cdots$$

The initial value of ***float compensation*** is ***0.0***.

```
float& pi(int n){
    float pi =0, sum_to_add;
    for(int k=0; k<=n; ++k){
        ~~pi = kahan~~
        sum_to_add = (16* pow(-1,k))/((2*k+1)* pow(5,2k+1));
        sum_to_add -=(4* pow(-1,k))/((2*k+1)* pow(239,2k+1));
        pi = kahan(pi, sum_to_add, compensation);
    }
    return pi;
}
```

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Use the backside, if needed

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Problem 2: Write a Java method ***public static double[] expReg(double[] data)*** that takes as its argument an array of data points ***double[] data***, and returns a two-element array – the first element being the exponent of an exponential regression and the second element being the amplitude. The exponential regression approximates the data points by a formula

$$y = a\, e^{mx},$$

where the exponent ***m*** and the amplitude ***a*** are computed as

$$m = \frac{\overline{xy} - \bar{x}\,\bar{y}}{\overline{x^2} - \bar{x}^2}, a = \bar{y} - m\bar{x}$$

Here $\bar{x}$ is the mean of the ***x*** coordinates, $\bar{y}$ is the mean of the natural logarithm of ***y*** coordinates, $\overline{x^2}$ is the mean of the squares of the ***x*** coordinates, and $\overline{xy}$ is the mean of the products of the ***x*** and natural logarithm of ***y*** coordinates. Use the element indices of the array ***double[] data*** as ***x*** coordinates and the element values as ***y*** coordinates. For natural logarithm, use the method ***double Math.log()***.

Both result elements are zeros, if at least one data element is non-positive.

```
public static double[] expReg(double[] data){
  double meanX = 0, meanLogY = 0, meanXSquare = 0, meanXY = 0;
  for(int i=0; i< data.length; i++){
     meanX += i;
     meanLogY += Math.log(data[i]);
     meanXSquare += i*i;
     meanXY += i*Math.log(data[i]);
  }
  meanX /= data.length;
  meanLogY /= data.length;
  meanXSquare /= data.length;
  meanXY /= data.length;
  double[] result = new double[2];
  result[0] = (meanXY-(meanX*meanLogY))/((meanXSquare-(meanX*meanX));
  result[1] = meanLogY-(result[0]*meanX);
  return result;
}
```

if negative ?

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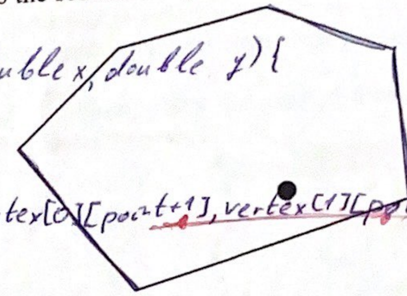
Problem 3: Write a Java function ***public static boolean isInside(double[][] vertex, double x, double y)*** that takes as its argument a ***2-by-n*** array of a convex polygon's vertex coordinates ***double[][] vertex*** – the *x* coordinates in the first row and *y* coordinates in the second row, and ***double x*** and ***double y*** coordinates of a point. It checks, if the point is inside the polygon.

Assume and use a method ***boolean toLeft(double x1, double y1, double x2, double y2, double x0, double y0)*** that takes as its arguments coordinates of three points and returns ***true***, if the third point ***(x0, y0)*** is in the left-hand side, when moving from the first point ***(x1, y1)*** to the second one ***(x2, y2)***; and ***false***, if it is in the right-hand side.



```
public static boolean isInside(double[][] vertex, double x, double y){
  for(int point=0; point<vertex[0].length-1; point++){
    if(!toLeft(vertex[0][point], vertex[1][point], vertex[0][point+1], vertex[1][point+1],
         x, y)){
       return false;
    }
  }
  return toLeft(vertex[0][vertex[0].length-1], vertex[1][vertex[0].length-1],
            vertex[0][0], vertex[1][0], x, y);
}.
```

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Problem 4: Write a Java method ***public static void magicOdd(int[][] square)*** that creates a magic square of an ***odd*** size using the following algorithm:

1. The number ***1*** goes in the middle of the top row;
2. All numbers are then placed one ***column to the right*** and ***one row up*** from the previous number;
3. Whenever the next number placement is above the top row, stay in the same column and place the number in the bottom row (note the place of ***2*** instead of the shaded location);
4. Whenever the next number placement is outside of the rightmost column, stay in the same row and place the number in the leftmost column (note the place of ***3*** instead of the shaded location);
5. When encountering an already filled-in square, place the next number directly below the previous number;
6. When the next number position is outside both a row and a column, place the number directly beneath the previous number (note the place of ***7*** instead of the shaded location).

y

	9	2	7
8	1	6	8
3	5	7	3
4	9	2	

X

I assumed square is filled with 0-s

```
public static void magicOdd(int[][] square) {
  int posX = 0;
  int posY = square.length / 2 +1;
  int size = square.length; square[posX][posY] = 1;
  for(int counter = 2; counter <= size * size; counter++) {
    ~~if(posY+1 == size)~~
      ~~posY=0;~~
    ~~else~~
      ~~posX++;~~
    ~~if(posX-1==-1)~~
      ~~posX~~
    posY++;
    if(posY == size){
      posY = 0;}
    posX--;
    if(posX == -1){
      posX = size-1;}
    if(square[posX][posY] == 0){          // cell is empty
      square[posX][posY] = counter;}
                                           // cell is not empty
    else{
      posY--; if(posY == -1){posY = size-1}
      posX++; if(posX == size){posX=0}   // bring to back position
      posX++; if(posX == size){posX=0}   // go down a row
      square[posX][posY] = counter;
    }
  }
}
```

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Use the backside, if needed

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