Computer Vision
Project 8: K Curvature

Algorithm for Computing K curvature

1. Count the number of points in the image.
2. Store them in an array.
3. Initialize your starting point, middle and end/tail point.
    a. Q=0.
    b. P = K curvature.
    c. R = 2 * K. // number of spaces from the starting point Q.
4. Compute the curvature of Q to P and P to R.

Source Code

```cpp
#include <iostream>
#include <fstream>
#include <string>
#include <cmath>

using namespace std;

class boundaryPt{
    friend class kCurvature;


    int x;
    int y;
    int lm;
    int corner;
    double curvature;




};
class kCurvature{
    public:
        int K;
        int numPts;
        boundaryPt* PtAry;
        double neigh[5];
```

```cpp
    kCurvature(int k_Curvature){

        this->K = k_Curvature;

    }


  void storePt(int x, int y, int index) {

        //Store into pointer array

        PtAry[index].x = x;

        PtAry[index].y = y;

  }


  int countPts(fstream &fstream) {


      string line;

      //count the number of points in the inputFile

      while(getline(fstream,line)) {

        numPts++;

      }


      return numPts;

  }


//Begin
  void initialization(fstream &inputFile) {
```

```cpp
        numPts = countPts(inputFile);


    PtAry = new boundaryPt [numPts];



    inputFile.flush();

    inputFile.clear();

    inputFile.seekp(14,inputFile.beg);


    int index = 0;

    while(index != numPts){

        int x;

        int y;


        inputFile >> x;

        inputFile >> y;


        storePt(x, y, index);

        index++;

    }

}


void printArray(ofstream &write) {

    //Display contents of array

  for (int i = 0; i < numPts; i++)

  {

    write << PtAry[i].x << " " <<  PtAry[i].y << endl;
```

```cpp
    }
  }


  void cornerDetection(ofstream &of) {
      int Q = 0;
      int P = K;
      int R = 2 * K;



    int index = P;
    while(P != K - 1) {


      double c = computeCurvature(Q, P, R);
      PtAry[index].curvature = c;


      of << "Q:" << Q << "  P:" << P << "  R:" << R << " index:" << index << " x:" << PtAry[index].x << "  y:" <<
        PtAry[index].y << "  curvature:" << PtAry[index].curvature << endl;


      Q = (Q + 1) % numPts;
      P = (P + 1) % numPts;
      R = (R + 1) % numPts;
      index = (index + 1) % numPts;
    }



  }
```

```java
double computeCurvature(int q, int p, int r) {

    double pCurvature = 0;


    //look at the points and use K to get the next point.
    int qRow = PtAry[q].x;  //r1
    int qCol = PtAry[q].y;  //c1


    int pRow = PtAry[p].x;  //r2
    int pCol = PtAry[p].y;  //c2


    int rRow = PtAry[r].x;  //r3
    int rCol = PtAry[r].y;  //c3


    int c1_c2 = qCol - pCol;
    int r1_r2 = (qRow - pRow);



    double c2_c3 = pCol - rCol;
    double r2_r3 = pRow - rRow;


    //too many errors
    if(r2_r3 == 0 ) {

        r2_r3 = 1;

    }


    if(r1_r2 == 0) {
```

```
        r1_r2 = 1;

      }

       pCurvature = abs((((c1_c2) / (r1_r2) ) - ((c2_c3) / (r2_r3))));


    return pCurvature;

  }


  void localMaxima() {


    for  (int j = 0; j < numPts - 1; j++) {


        neigh[0] = PtAry[j - 2].curvature;

        neigh[1] = PtAry[j - 1].curvature;

        neigh[2] = PtAry[j].   curvature;

        neigh[3] = PtAry[j + 1].curvature;

        neigh[4] = PtAry[j + 2].curvature;


        double max = PtAry[j].   curvature;

//Problem here. I've debugged the entire code and the problem lives here as the array does not
want to change local

        if(j == 0){

          for( int m = 2; m < 5;m++){


            if(max >= neigh[m]){

              PtAry[j].lm = 1;

            }else{
```

```
                    PtAry[j].lm = 0;

                    break;

                }

            }

        }else if(j == 1){

            for( int m = 1; m < 5;m++){

                if(max >= neigh[m]){

                    PtAry[j].lm = 1;

                }else{

                    PtAry[j].lm = 0;

                    break;


                }

            }

        }else{

            for( int m = 0; m < 5;m++){

                if(max >= neigh[m]){

                    PtAry[j].lm = 1;

                }else{

                    PtAry[j].lm = 0;

                    break;


                }

            }

        }

    }

}
```

```cpp
void markCorner() {
    for (int i = 0; i <= numPts - 1; i++) {


        if (i == 0) {
            if (PtAry[i].lm == 1 || PtAry[i + 1].lm == 1) {

                PtAry[i].corner = 9;

            } else {

                PtAry[i].corner = 1;

            }

        } else {

            if ((PtAry[i].lm == 1) && (!PtAry[i + 1].lm == 1 != !PtAry[i - 1].lm == 1)) {

                PtAry[i].corner = 9;

            } else {

                PtAry[i].corner = 1;

            }

            // }

        }

    }

}


void printBoundary(ofstream &of) {
    for(int i = 0; i < numPts; i++){
        of << " x:" << PtAry[i].x  << " y:" << PtAry[i].y << " corner:" <<  PtAry[i].corner <<

        " curve:" <<  PtAry[i].curvature <<  endl;

    }
```

```cpp
    }


    void display(int ** imageArray) {
      for(int i = 0; i < numPts; i++){

        imageArray[PtAry[i].x][PtAry[i].y] = PtAry[i].corner;



      }
    }


    void prettyPrint(ofstream &of, int r, int c, int **array) {
        for( int i = 0; i < r; i++){

          for( int j = 0; j < c; j++){

            if(array[i][j] == 0){

              of << ". ";

            }else{

              of << array[i][j] << " ";

            }

          }

          of << endl;

        }

    }
};


int main(int argc, char *argv[]) {


  //Console arguments.
  string dataFile = argv[1];
```

```cpp
    string outFile = argv[2];

    string outFile1 = argv[3];

    string outFile2 = argv[4];


    //InputFile values

    int numRows;

    int numCols;

    int minVal;

    int maxVal;

    int label;


    //Dynamic array for corner values

    int** imageAry;




    //User console input

    int k_Curvature;

    cout << "Please enter a K to be used in the K-curvature computation :";


    while( !(cin >> k_Curvature)){

        cin.clear();

        cin.ignore();

        cout << "K should be an number. Please enter a number." << endl;

    }
```

```cpp
//Obtain user input of K
if(argc < 5)
{
    cout << "You are missing the [K] curvature value. Please enter!" << endl;
}


//Open input file stream
fstream inputFile;
inputFile.open("data.txt");


inputFile >> numRows >> numCols >> minVal >> maxVal >> label;



imageAry = new int *[numRows];
for(int row = 0; row < numRows; row++){
    imageAry[row] = new int[numCols];
}


for(int i = 0; i < numRows; i++){
    for(int j = 0; j < numCols; j++){
        imageAry[i][j] = 0;
    }
}
//Open output file stream
ofstream outputFile_1 (outFile);
ofstream outputFile_2 (outFile1);
ofstream outputFile_3 (outFile2);
```

```cpp
//K curvature class
kCurvature kC(k_Curvature);

kC.initialization(inputFile);
kC.printArray(outputFile_3);
kC.cornerDetection(outputFile_3);
kC.localMaxima();
kC.markCorner();
kC.printBoundary(outputFile_1);
kC.display(imageAry);
kC.prettyPrint(outputFile_2, numRows, numCols,imageAry);

inputFile.close();
outputFile_1.close();
outputFile_2.close();
outputFile_3.close();
return 0;
}
```

```
x:6 y:6 corner:9 curve:4
x:7 y:6 corner:1 curve:3
x:8 y:6 corner:1 curve:1
x:9 y:6 corner:1 curve:0
x:10 y:6 corner:1 curve:0
x:11 y:6 corner:9 curve:0
x:12 y:6 corner:1 curve:0
x:13 y:6 corner:1 curve:0
x:14 y:6 corner:1 curve:0
x:15 y:6 corner:1 curve:0
x:16 y:6 corner:1 curve:0
x:17 y:6 corner:1 curve:0
x:18 y:6 corner:9 curve:0
x:19 y:6 corner:1 curve:0
x:20 y:6 corner:1 curve:0
x:21 y:6 corner:1 curve:0.25
x:22 y:6 corner:1 curve:0.666667
x:23 y:6 corner:1 curve:1.5
x:24 y:6 corner:1 curve:4
x:25 y:6 corner:1 curve:5
x:25 y:7 corner:1 curve:5
x:25 y:8 corner:1 curve:5
x:25 y:9 corner:1 curve:6
x:25 y:10 corner:1 curve:9
x:25 y:11 corner:1 curve:0
x:25 y:12 corner:1 curve:0
x:25 y:13 corner:9 curve:0
x:25 y:14 corner:1 curve:0
x:25 y:15 corner:1 curve:0
x:25 y:16 corner:1 curve:0
x:25 y:17 corner:1 curve:0
x:25 y:18 corner:1 curve:0
x:25 y:19 corner:1 curve:0
x:25 y:20 corner:1 curve:0
x:25 y:21 corner:1 curve:0
x:25 y:22 corner:1 curve:0
x:25 y:23 corner:1 curve:0
x:25 y:24 corner:1 curve:0
x:25 y:25 corner:1 curve:0
x:25 y:26 corner:1 curve:0
x:25 y:27 corner:1 curve:0
x:25 y:28 corner:9 curve:0
x:25 y:29 corner:1 curve:0
x:25 y:30 corner:1 curve:0
x:25 y:31 corner:1 curve:1
x:25 y:32 corner:1 curve:3.5
x:25 y:33 corner:1 curve:4.33333
x:25 y:34 corner:1 curve:4.75
x:25 y:35 corner:1 curve:5
x:24 y:35 corner:1 curve:4
x:23 y:35 corner:1 curve:1
x:22 y:35 corner:1 curve:0
```

```
x:21 y:35 corner:1 curve:0
x:20 y:35 corner:9 curve:0
x:19 y:35 corner:1 curve:0
x:18 y:35 corner:1 curve:0
x:17 y:35 corner:1 curve:0
x:16 y:35 corner:1 curve:0
x:15 y:35 corner:1 curve:0
x:14 y:35 corner:1 curve:0
x:13 y:35 corner:9 curve:0
x:12 y:35 corner:1 curve:0
x:11 y:35 corner:1 curve:0
x:10 y:35 corner:1 curve:0.25
x:9 y:35 corner:1 curve:0.666667
x:8 y:35 corner:1 curve:1.5
x:7 y:35 corner:1 curve:4
x:6 y:35 corner:9 curve:5
x:6 y:34 corner:1 curve:5
x:6 y:33 corner:9 curve:5
x:6 y:32 corner:1 curve:4
x:6 y:31 corner:1 curve:1
x:6 y:30 corner:1 curve:0
x:6 y:29 corner:1 curve:0
x:6 y:28 corner:9 curve:0
x:6 y:27 corner:1 curve:0
x:6 y:26 corner:1 curve:0
x:6 y:25 corner:1 curve:0
x:6 y:24 corner:1 curve:0
x:6 y:23 corner:1 curve:0
x:6 y:22 corner:1 curve:0
x:6 y:21 corner:1 curve:0
x:6 y:20 corner:1 curve:0
x:6 y:19 corner:1 curve:0
x:6 y:18 corner:1 curve:0
x:6 y:17 corner:1 curve:0
x:6 y:16 corner:1 curve:0
x:6 y:15 corner:1 curve:0
x:6 y:14 corner:9 curve:0
x:6 y:13 corner:1 curve:0
x:6 y:12 corner:1 curve:0
x:6 y:11 corner:1 curve:1
x:6 y:10 corner:1 curve:1
x:6 y:9 corner:1 curve:8
x:6 y:8 corner:1 curve:6
x:6 y:7 corner:1 curve:5.33333
x:6 y:7 corner:1 curve:4.25
```

Output for data A (K = 5)

```
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . 9 1 1 1 1 1 1 1 9 1 1 1 1 1 1 1 1 1 1 1 1 1 9 1 1 1 1 9 1 9 . . . .
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. . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . 9 . . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . 9 . . . .
. . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . 1 . . . . . . . . . . . . | . . . . . . . . . . . . . . . 1 . . . .
. . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . 9 . . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . 9 . . . .
. . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . 1 . . . . . . . . . . . . . . . . . . . . . . . . . . . 1 . . . .
. . . . . 1 1 1 1 1 1 1 1 9 1 1 1 1 1 1 1 1 1 1 1 1 1 9 1 1 1 1 1 1 1 . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
```

```
6   6
7   6
8   6
9   6
10  6
11  6
12  6
13  6
14  6
15  6
16  6
17  6
18  6
19  6
20  6
21  6
22  6
23  6
24  6
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```

```
23 35
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6 16
6 15
6 14
6 13
6 12
6 11
6 10
6 9
6 8
6 7
6 7
Q:0  P:5   R:10 index:5  x:11  y:6  curvature:0
Q:1  P:6   R:11 index:6  x:12  y:6  curvature:0
Q:2  P:7   R:12 index:7  x:13  y:6  curvature:0
Q:3  P:8   R:13 index:8  x:14  y:6  curvature:0
Q:4  P:9   R:14 index:9  x:15  y:6  curvature:0
Q:5  P:10  R:15 index:10 x:16  y:6  curvature:0
Q:6  P:11  R:16 index:11 x:17  y:6  curvature:0
```

```
Q:7   P:12  R:17 index:12 x:18  y:6   curvature:0
Q:8   P:13  R:18 index:13 x:19  y:6   curvature:0
Q:9   P:14  R:19 index:14 x:20  y:6   curvature:0
Q:10  P:15  R:20 index:15 x:21  y:6   curvature:0.25
Q:11  P:16  R:21 index:16 x:22  y:6   curvature:0.666667
Q:12  P:17  R:22 index:17 x:23  y:6   curvature:1.5
Q:13  P:18  R:23 index:18 x:24  y:6   curvature:4
Q:14  P:19  R:24 index:19 x:25  y:6   curvature:5
Q:15  P:20  R:25 index:20 x:25  y:7   curvature:5
Q:16  P:21  R:26 index:21 x:25  y:8   curvature:5
Q:17  P:22  R:27 index:22 x:25  y:9   curvature:6
Q:18  P:23  R:28 index:23 x:25  y:10  curvature:9
Q:19  P:24  R:29 index:24 x:25  y:11  curvature:0
Q:20  P:25  R:30 index:25 x:25  y:12  curvature:0
Q:21  P:26  R:31 index:26 x:25  y:13  curvature:0
Q:22  P:27  R:32 index:27 x:25  y:14  curvature:0
Q:23  P:28  R:33 index:28 x:25  y:15  curvature:0
Q:24  P:29  R:34 index:29 x:25  y:16  curvature:0
Q:25  P:30  R:35 index:30 x:25  y:17  curvature:0
Q:26  P:31  R:36 index:31 x:25  y:18  curvature:0
Q:27  P:32  R:37 index:32 x:25  y:19  curvature:0
Q:28  P:33  R:38 index:33 x:25  y:20  curvature:0
Q:29  P:34  R:39 index:34 x:25  y:21  curvature:0
Q:30  P:35  R:40 index:35 x:25  y:22  curvature:0
Q:31  P:36  R:41 index:36 x:25  y:23  curvature:0
Q:32  P:37  R:42 index:37 x:25  y:24  curvature:0
Q:33  P:38  R:43 index:38 x:25  y:25  curvature:0
Q:34  P:39  R:44 index:39 x:25  y:26  curvature:0
Q:35  P:40  R:45 index:40 x:25  y:27  curvature:0
Q:36  P:41  R:46 index:41 x:25  y:28  curvature:0
Q:37  P:42  R:47 index:42 x:25  y:29  curvature:0
Q:38  P:43  R:48 index:43 x:25  y:30  curvature:0
Q:39  P:44  R:49 index:44 x:25  y:31  curvature:1
Q:40  P:45  R:50 index:45 x:25  y:32  curvature:3.5
Q:41  P:46  R:51 index:46 x:25  y:33  curvature:4.33333
Q:42  P:47  R:52 index:47 x:25  y:34  curvature:4.75
Q:43  P:48  R:53 index:48 x:25  y:35  curvature:5
Q:44  P:49  R:54 index:49 x:24  y:35  curvature:4
Q:45  P:50  R:55 index:50 x:23  y:35  curvature:1
Q:46  P:51  R:56 index:51 x:22  y:35  curvature:0
Q:47  P:52  R:57 index:52 x:21  y:35  curvature:0
Q:48  P:53  R:58 index:53 x:20  y:35  curvature:0
Q:49  P:54  R:59 index:54 x:19  y:35  curvature:0
Q:50  P:55  R:60 index:55 x:18  y:35  curvature:0
Q:51  P:56  R:61 index:56 x:17  y:35  curvature:0
Q:52  P:57  R:62 index:57 x:16  y:35  curvature:0
Q:53  P:58  R:63 index:58 x:15  y:35  curvature:0
Q:54  P:59  R:64 index:59 x:14  y:35  curvature:0
Q:55  P:60  R:65 index:60 x:13  y:35  curvature:0
Q:56  P:61  R:66 index:61 x:12  y:35  curvature:0
Q:57  P:62  R:67 index:62 x:11  y:35  curvature:0
Q:58  P:63  R:68 index:63 x:10  y:35  curvature:0.25
Q:59  P:64  R:69 index:64 x:9   y:35  curvature:0.666667
Q:60  P:65  R:70 index:65 x:8   y:35  curvature:1.5
```
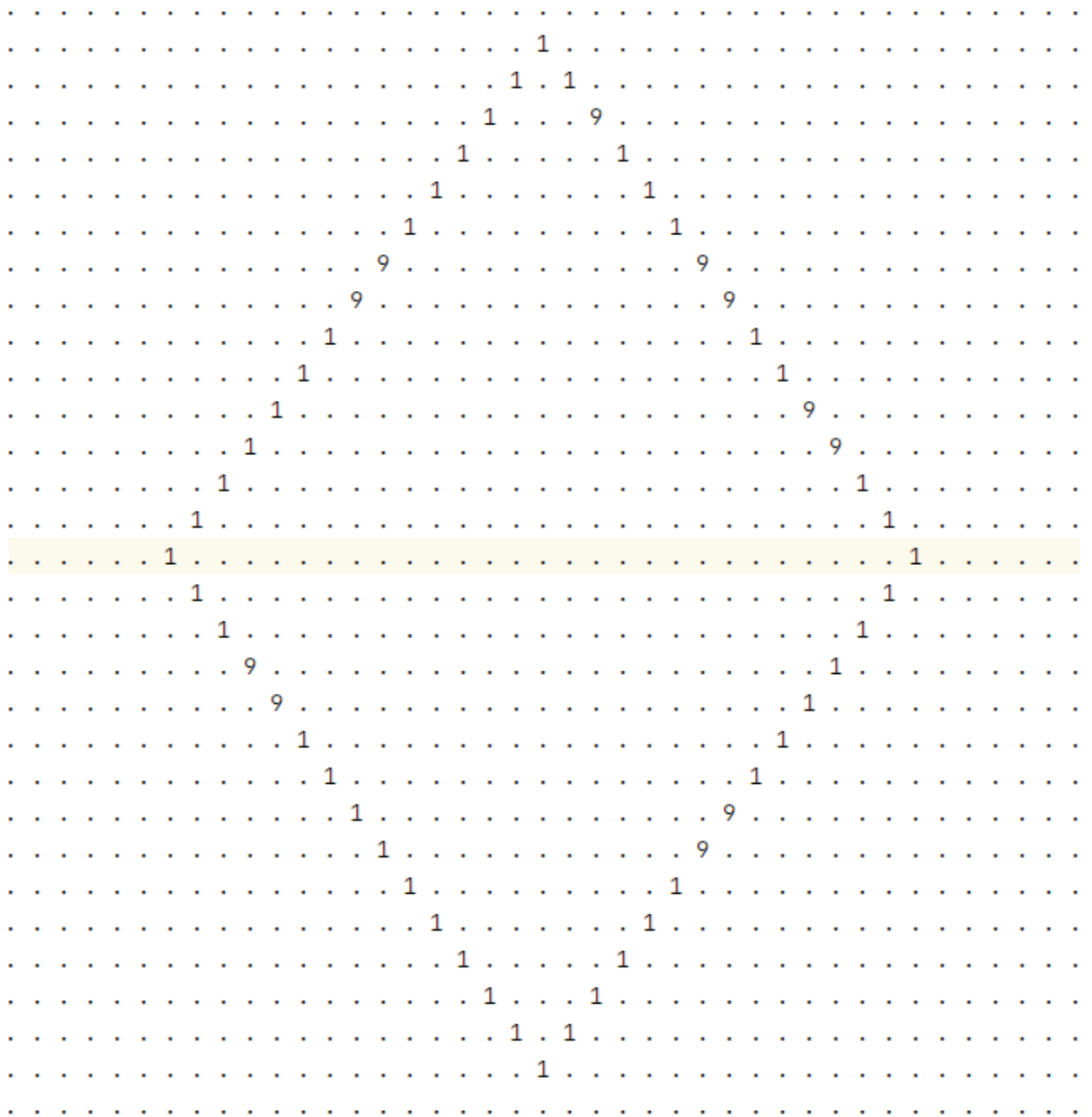
```
Q:61  P:66  R:71 index:66 x:7  y:35  curvature:4
Q:62  P:67  R:72 index:67 x:6  y:35  curvature:5
Q:63  P:68  R:73 index:68 x:6  y:34  curvature:5
Q:64  P:69  R:74 index:69 x:6  y:33  curvature:5
Q:65  P:70  R:75 index:70 x:6  y:32  curvature:4
Q:66  P:71  R:76 index:71 x:6  y:31  curvature:1
Q:67  P:72  R:77 index:72 x:6  y:30  curvature:0
Q:68  P:73  R:78 index:73 x:6  y:29  curvature:0
Q:69  P:74  R:79 index:74 x:6  y:28  curvature:0
Q:70  P:75  R:80 index:75 x:6  y:27  curvature:0
Q:71  P:76  R:81 index:76 x:6  y:26  curvature:0
Q:72  P:77  R:82 index:77 x:6  y:25  curvature:0
Q:73  P:78  R:83 index:78 x:6  y:24  curvature:0
Q:74  P:79  R:84 index:79 x:6  y:23  curvature:0
Q:75  P:80  R:85 index:80 x:6  y:22  curvature:0
Q:76  P:81  R:86 index:81 x:6  y:21  curvature:0
Q:77  P:82  R:87 index:82 x:6  y:20  curvature:0
Q:78  P:83  R:88 index:83 x:6  y:19  curvature:0
Q:79  P:84  R:89 index:84 x:6  y:18  curvature:0
Q:80  P:85  R:90 index:85 x:6  y:17  curvature:0
Q:81  P:86  R:91 index:86 x:6  y:16  curvature:0
Q:82  P:87  R:92 index:87 x:6  y:15  curvature:0
Q:83  P:88  R:93 index:88 x:6  y:14  curvature:0
Q:84  P:89  R:94 index:89 x:6  y:13  curvature:0
Q:85  P:90  R:95 index:90 x:6  y:12  curvature:0
Q:86  P:91  R:96 index:91 x:6  y:11  curvature:1
Q:87  P:92  R:0 index:92 x:6  y:10  curvature:1
Q:88  P:93  R:1 index:93 x:6  y:9  curvature:8
Q:89  P:94  R:2 index:94 x:6  y:8  curvature:6
Q:90  P:95  R:3 index:95 x:6  y:7  curvature:5.33333
Q:91  P:96  R:4 index:96 x:6  y:7  curvature:4.25
Q:92  P:0  R:5 index:0 x:6  y:6  curvature:4
Q:93  P:1  R:6 index:1 x:7  y:6  curvature:3
Q:94  P:2  R:7 index:2 x:8  y:6  curvature:1
Q:95  P:3  R:8 index:3 x:9  y:6  curvature:0
```

Output for data B

x:1 y:20 corner:1 curve:2

x:2 y:19 corner:1 curve:3

x:3 y:18 corner:1 curve:5

x:4 y:17 corner:1 curve:1

x:5 y:16 corner:1 curve:0

x:6 y:15 corner:1 curve:0

x:7 y:14 corner:9 curve:0

x:8 y:13 corner:9 curve:0

x:9 y:12 corner:1 curve:0

x:10 y:11 corner:1 curve:0

x:11 y:10 corner:1 curve:0.4

x:12 y:9 corner:1 curve:0.8

x:13 y:8 corner:1 curve:1.2

x:14 y:7 corner:1 curve:1.6

x:15 y:6 corner:1 curve:2

x:16 y:7 corner:1 curve:1

x:17 y:8 corner:1 curve:1

x:18 y:9 corner:9 curve:1

x:19 y:10 corner:9 curve:1

x:20 y:11 corner:1 curve:0

x:21 y:12 corner:1 curve:0

x:22 y:13 corner:1 curve:0

x:23 y:14 corner:1 curve:0

x:24 y:15 corner:1 curve:0

x:25 y:16 corner:1 curve:0.666667

x:26 y:17 corner:1 curve:4

x:27 y:18 corner:1 curve:6

x:28 y:19 corner:1 curve:2.66667

x:29 y:20 corner:1 curve:2

x:28 y:21 corner:1 curve:2

x:27 y:22 corner:1 curve:6

x:26 y:23 corner:1 curve:4

x:25 y:24 corner:1 curve:0

x:24 y:25 corner:1 curve:0

x:23 y:26 corner:9 curve:0

x:22 y:27 corner:9 curve:0

x:21 y:28 corner:1 curve:0

x:20 y:29 corner:1 curve:0

x:19 y:30 corner:1 curve:0.4

x:18 y:31 corner:1 curve:0.8

x:17 y:32 corner:1 curve:1.2

x:16 y:33 corner:1 curve:1.6

x:15 y:34 corner:1 curve:2

x:14 y:33 corner:1 curve:1

x:13 y:32 corner:1 curve:1

x:12 y:31 corner:9 curve:1

x:11 y:30 corner:9 curve:1

x:10 y:29 corner:1 curve:0

x:9 y:28 corner:1 curve:0

x:8 y:27 corner:9 curve:0

x:7 y:26 corner:9 curve:0

x:6 y:25 corner:1 curve:0

x:5 y:24 corner:1 curve:0

x:4 y:23 corner:1 curve:1

x:3 y:22 corner:9 curve:3

x:2 y:21 corner:9 curve:3

x:2 y:21 corner:1 curve:2.66667

```
1 20
2 19
3 18
4 17
5 16
6 15
7 14
8 13
9 12
10 11
11 10
12 9
13 8
14 7
15 6
16 7
17 8
18 9
19 10
20 11
21 12
22 13
23 14
24 15
25 16
26 17
27 18
28 19
29 20
28 21
27 22
26 23
25 24
24 25
23 26
22 27
21 28
20 29
19 30
18 31
17 32
16 33
15 34
14 33
13 32
12 31
11 30
10 29
9 28
8 27
7 26
6 25
5 24
4 23
```

```
3 22
2 21
2 21
Q:0   P:5   R:10 index:5  x:6   y:15   curvature:0
Q:1   P:6   R:11 index:6  x:7   y:14   curvature:0
Q:2   P:7   R:12 index:7  x:8   y:13   curvature:0
Q:3   P:8   R:13 index:8  x:9   y:12   curvature:0
Q:4   P:9   R:14 index:9  x:10  y:11   curvature:0
Q:5   P:10  R:15 index:10 x:11  y:10   curvature:0.4
Q:6   P:11  R:16 index:11 x:12  y:9    curvature:0.8
Q:7   P:12  R:17 index:12 x:13  y:8    curvature:1.2
Q:8   P:13  R:18 index:13 x:14  y:7    curvature:1.6
Q:9   P:14  R:19 index:14 x:15  y:6    curvature:2
Q:10  P:15  R:20 index:15 x:16  y:7    curvature:1
Q:11  P:16  R:21 index:16 x:17  y:8    curvature:1
Q:12  P:17  R:22 index:17 x:18  y:9    curvature:1
Q:13  P:18  R:23 index:18 x:19  y:10   curvature:1
Q:14  P:19  R:24 index:19 x:20  y:11   curvature:0
Q:15  P:20  R:25 index:20 x:21  y:12   curvature:0
Q:16  P:21  R:26 index:21 x:22  y:13   curvature:0
Q:17  P:22  R:27 index:22 x:23  y:14   curvature:0
Q:18  P:23  R:28 index:23 x:24  y:15   curvature:0
Q:19  P:24  R:29 index:24 x:25  y:16   curvature:0.666667
Q:20  P:25  R:30 index:25 x:26  y:17   curvature:4
Q:21  P:26  R:31 index:26 x:27  y:18   curvature:6
Q:22  P:27  R:32 index:27 x:28  y:19   curvature:2.66667
Q:23  P:28  R:33 index:28 x:29  y:20   curvature:2
Q:24  P:29  R:34 index:29 x:28  y:21   curvature:2
Q:25  P:30  R:35 index:30 x:27  y:22   curvature:6
Q:26  P:31  R:36 index:31 x:26  y:23   curvature:4
Q:27  P:32  R:37 index:32 x:25  y:24   curvature:0
Q:28  P:33  R:38 index:33 x:24  y:25   curvature:0
Q:29  P:34  R:39 index:34 x:23  y:26   curvature:0
Q:30  P:35  R:40 index:35 x:22  y:27   curvature:0
Q:31  P:36  R:41 index:36 x:21  y:28   curvature:0
Q:32  P:37  R:42 index:37 x:20  y:29   curvature:0
Q:33  P:38  R:43 index:38 x:19  y:30   curvature:0.4
Q:34  P:39  R:44 index:39 x:18  y:31   curvature:0.8
Q:35  P:40  R:45 index:40 x:17  y:32   curvature:1.2
Q:36  P:41  R:46 index:41 x:16  y:33   curvature:1.6
Q:37  P:42  R:47 index:42 x:15  y:34   curvature:2
Q:38  P:43  R:48 index:43 x:14  y:33   curvature:1
Q:39  P:44  R:49 index:44 x:13  y:32   curvature:1
Q:40  P:45  R:50 index:45 x:12  y:31   curvature:1
Q:41  P:46  R:51 index:46 x:11  y:30   curvature:1
Q:42  P:47  R:52 index:47 x:10  y:29   curvature:0
Q:43  P:48  R:53 index:48 x:9   y:28   curvature:0
Q:44  P:49  R:54 index:49 x:8   y:27   curvature:0
Q:45  P:50  R:55 index:50 x:7   y:26   curvature:0
Q:46  P:51  R:56 index:51 x:6   y:25   curvature:0
Q:47  P:52  R:0 index:52 x:5   y:24   curvature:0
Q:48  P:53  R:1 index:53 x:4   y:23   curvature:1
Q:49  P:54  R:2 index:54 x:3   y:22   curvature:3
Q:50  P:55  R:3 index:55 x:2   y:21   curvature:3
```

```
Q:51  P:56  R:4 index:56 x:2  y:21  curvature:2.66667
Q:52  P:0  R:5 index:0 x:1  y:20  curvature:2
Q:53  P:1  R:6 index:1 x:2  y:19  curvature:3
Q:54  P:2  R:7 index:2 x:3  y:18  curvature:5
Q:55  P:3  R:8 index:3 x:4  y:17  curvature:1
```

Output for Data C

```
x:5 y:5 corner:9 curve:4
x:6 y:5 corner:1 curve:3
x:7 y:5 corner:1 curve:1
x:8 y:5 corner:1 curve:0
x:9 y:5 corner:1 curve:0
x:10 y:5 corner:1 curve:0
x:11 y:5 corner:1 curve:0.2
x:12 y:5 corner:1 curve:0.4
x:13 y:5 corner:1 curve:0.6
x:14 y:5 corner:1 curve:0.8
x:15 y:5 corner:1 curve:1
x:16 y:6 corner:1 curve:0.6
x:17 y:7 corner:1 curve:0.2
x:18 y:8 corner:1 curve:0.2
x:19 y:9 corner:1 curve:0.6
x:20 y:10 corner:1 curve:2
x:21 y:9 corner:1 curve:0.8
x:22 y:8 corner:1 curve:0.6
x:23 y:7 corner:1 curve:0.4
x:24 y:6 corner:1 curve:0.2
x:25 y:5 corner:1 curve:1
x:26 y:5 corner:1 curve:0
x:27 y:5 corner:1 curve:0
x:28 y:5 corner:1 curve:0
x:29 y:5 corner:1 curve:0
x:30 y:5 corner:1 curve:0
x:31 y:5 corner:1 curve:0.25
x:32 y:5 corner:1 curve:0.666667
x:33 y:5 corner:1 curve:1.5
x:34 y:5 corner:1 curve:4
x:35 y:5 corner:1 curve:5
x:35 y:6 corner:1 curve:5
x:35 y:7 corner:1 curve:5
x:35 y:8 corner:1 curve:6
x:35 y:9 corner:1 curve:9
x:35 y:10 corner:1 curve:0
x:35 y:11 corner:1 curve:0
x:35 y:12 corner:9 curve:0
x:35 y:13 corner:1 curve:0
x:35 y:14 corner:1 curve:0
x:35 y:15 corner:1 curve:0
x:35 y:16 corner:1 curve:0
x:35 y:17 corner:1 curve:0
x:35 y:18 corner:1 curve:0
x:35 y:19 corner:1 curve:0
x:35 y:20 corner:1 curve:0
x:35 y:21 corner:1 curve:0
x:35 y:22 corner:9 curve:0
```

```
x:35 y:23 corner:1 curve:0
x:35 y:24 corner:1 curve:0
x:35 y:25 corner:1 curve:1
x:35 y:26 corner:1 curve:3.5
x:35 y:27 corner:1 curve:4.33333
x:35 y:28 corner:1 curve:4.75
x:35 y:29 corner:1 curve:5
x:34 y:29 corner:1 curve:4
x:33 y:29 corner:1 curve:1
x:32 y:29 corner:1 curve:0
x:31 y:29 corner:1 curve:0
x:30 y:29 corner:1 curve:0
x:29 y:29 corner:1 curve:0.2
x:28 y:29 corner:1 curve:0.4
x:27 y:29 corner:1 curve:0.6
x:26 y:29 corner:1 curve:0.8
x:25 y:29 corner:1 curve:1
x:24 y:30 corner:1 curve:0.6
x:23 y:31 corner:1 curve:0.2
x:22 y:32 corner:1 curve:0.2
x:21 y:33 corner:1 curve:0.6
x:20 y:34 corner:1 curve:2
x:19 y:33 corner:1 curve:0.8
x:18 y:32 corner:1 curve:0.6
x:17 y:31 corner:1 curve:0.4
x:16 y:30 corner:1 curve:0.2
x:15 y:29 corner:1 curve:1
x:14 y:29 corner:1 curve:0
x:13 y:29 corner:1 curve:0
x:12 y:29 corner:1 curve:0
x:11 y:29 corner:1 curve:0
x:10 y:29 corner:1 curve:0
x:9 y:29 corner:1 curve:0.25
x:8 y:29 corner:1 curve:0.666667
x:7 y:29 corner:1 curve:1.5
x:6 y:29 corner:1 curve:4
x:5 y:29 corner:9 curve:5
x:5 y:28 corner:1 curve:5
x:5 y:27 corner:9 curve:5
x:5 y:26 corner:1 curve:4
x:5 y:25 corner:1 curve:1
x:5 y:24 corner:1 curve:0
x:5 y:23 corner:1 curve:0
x:5 y:22 corner:9 curve:0
x:5 y:21 corner:1 curve:0
x:5 y:20 corner:1 curve:0
x:5 y:19 corner:1 curve:0
x:5 y:18 corner:1 curve:0
x:5 y:17 corner:1 curve:0
x:5 y:16 corner:1 curve:0
x:5 y:15 corner:1 curve:0
x:5 y:14 corner:1 curve:0
x:5 y:13 corner:9 curve:0
x:5 y:12 corner:1 curve:0
```

```
x:5 y:11 corner:1 curve:0
x:5 y:10 corner:1 curve:1
x:5 y:9 corner:1 curve:1
x:5 y:8 corner:1 curve:8
x:5 y:7 corner:1 curve:6
x:5 y:6 corner:1 curve:5.33333
x:5 y:6 corner:1 curve:4.25
```

```
5  5
6  5
7  5
8  5
9  5
10  5
11  5
12  5
13  5
14  5
15  5
16  6
17  7
18  8
19  9
20  10
21  9
22  8
23  7
24  6
25  5
26  5
27  5
28  5
29  5
30  5
31  5
32  5
33  5
34  5
35  5
35  6
35  7
35  8
35  9
35  10
35  11
35  12
35  13
35  14
35  15
35  16
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35  26
```

```
35 27
35 28
35 29
34 29
33 29
32 29
31 29
30 29
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28 29
27 29
26 29
25 29
24 30
23 31
22 32
21 33
20 34
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18 32
17 31
16 30
15 29
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8 29
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6 29
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5 26
5 25
5 24
5 23
5 22
5 21
5 20
5 19
5 18
5 17
5 16
5 15
5 14
5 13
5 12
5 11
5 10
5 9
5 8
```

```
5 7
5 6
5 6


Q:0   P:5   R:10 index:5  x:10  y:5   curvature:0
Q:1   P:6   R:11 index:6  x:11  y:5   curvature:0.2
Q:2   P:7   R:12 index:7  x:12  y:5   curvature:0.4
Q:3   P:8   R:13 index:8  x:13  y:5   curvature:0.6
Q:4   P:9   R:14 index:9  x:14  y:5   curvature:0.8
Q:5   P:10  R:15 index:10 x:15  y:5   curvature:1
Q:6   P:11  R:16 index:11 x:16  y:6   curvature:0.6
Q:7   P:12  R:17 index:12 x:17  y:7   curvature:0.2
Q:8   P:13  R:18 index:13 x:18  y:8   curvature:0.2
Q:9   P:14  R:19 index:14 x:19  y:9   curvature:0.6
Q:10  P:15  R:20 index:15 x:20  y:10  curvature:2
Q:11  P:16  R:21 index:16 x:21  y:9   curvature:0.8
Q:12  P:17  R:22 index:17 x:22  y:8   curvature:0.6
Q:13  P:18  R:23 index:18 x:23  y:7   curvature:0.4
Q:14  P:19  R:24 index:19 x:24  y:6   curvature:0.2
Q:15  P:20  R:25 index:20 x:25  y:5   curvature:1
Q:16  P:21  R:26 index:21 x:26  y:5   curvature:0
Q:17  P:22  R:27 index:22 x:27  y:5   curvature:0
Q:18  P:23  R:28 index:23 x:28  y:5   curvature:0
Q:19  P:24  R:29 index:24 x:29  y:5   curvature:0
Q:20  P:25  R:30 index:25 x:30  y:5   curvature:0
Q:21  P:26  R:31 index:26 x:31  y:5   curvature:0.25
Q:22  P:27  R:32 index:27 x:32  y:5   curvature:0.666667
Q:23  P:28  R:33 index:28 x:33  y:5   curvature:1.5
Q:24  P:29  R:34 index:29 x:34  y:5   curvature:4
Q:25  P:30  R:35 index:30 x:35  y:5   curvature:5
Q:26  P:31  R:36 index:31 x:35  y:6   curvature:5
Q:27  P:32  R:37 index:32 x:35  y:7   curvature:5
Q:28  P:33  R:38 index:33 x:35  y:8   curvature:6
Q:29  P:34  R:39 index:34 x:35  y:9   curvature:9
Q:30  P:35  R:40 index:35 x:35  y:10  curvature:0
Q:31  P:36  R:41 index:36 x:35  y:11  curvature:0
Q:32  P:37  R:42 index:37 x:35  y:12  curvature:0
Q:33  P:38  R:43 index:38 x:35  y:13  curvature:0
Q:34  P:39  R:44 index:39 x:35  y:14  curvature:0
Q:35  P:40  R:45 index:40 x:35  y:15  curvature:0
Q:36  P:41  R:46 index:41 x:35  y:16  curvature:0
Q:37  P:42  R:47 index:42 x:35  y:17  curvature:0
Q:38  P:43  R:48 index:43 x:35  y:18  curvature:0
Q:39  P:44  R:49 index:44 x:35  y:19  curvature:0
Q:40  P:45  R:50 index:45 x:35  y:20  curvature:0
Q:41  P:46  R:51 index:46 x:35  y:21  curvature:0
Q:42  P:47  R:52 index:47 x:35  y:22  curvature:0
Q:43  P:48  R:53 index:48 x:35  y:23  curvature:0
Q:44  P:49  R:54 index:49 x:35  y:24  curvature:0
Q:45  P:50  R:55 index:50 x:35  y:25  curvature:1
Q:46  P:51  R:56 index:51 x:35  y:26  curvature:3.5
Q:47  P:52  R:57 index:52 x:35  y:27  curvature:4.33333
Q:48  P:53  R:58 index:53 x:35  y:28  curvature:4.75
```

```
Q:49   P:54   R:59  index:54  x:35  y:29   curvature:5
Q:50   P:55   R:60  index:55  x:34  y:29   curvature:4
Q:51   P:56   R:61  index:56  x:33  y:29   curvature:1
Q:52   P:57   R:62  index:57  x:32  y:29   curvature:0
Q:53   P:58   R:63  index:58  x:31  y:29   curvature:0
Q:54   P:59   R:64  index:59  x:30  y:29   curvature:0
Q:55   P:60   R:65  index:60  x:29  y:29   curvature:0.2
Q:56   P:61   R:66  index:61  x:28  y:29   curvature:0.4
Q:57   P:62   R:67  index:62  x:27  y:29   curvature:0.6
Q:58   P:63   R:68  index:63  x:26  y:29   curvature:0.8
Q:59   P:64   R:69  index:64  x:25  y:29   curvature:1
Q:60   P:65   R:70  index:65  x:24  y:30   curvature:0.6
Q:61   P:66   R:71  index:66  x:23  y:31   curvature:0.2
Q:62   P:67   R:72  index:67  x:22  y:32   curvature:0.2
Q:63   P:68   R:73  index:68  x:21  y:33   curvature:0.6
Q:64   P:69   R:74  index:69  x:20  y:34   curvature:2
Q:65   P:70   R:75  index:70  x:19  y:33   curvature:0.8
Q:66   P:71   R:76  index:71  x:18  y:32   curvature:0.6
Q:67   P:72   R:77  index:72  x:17  y:31   curvature:0.4
Q:68   P:73   R:78  index:73  x:16  y:30   curvature:0.2
Q:69   P:74   R:79  index:74  x:15  y:29   curvature:1
Q:70   P:75   R:80  index:75  x:14  y:29   curvature:0
Q:71   P:76   R:81  index:76  x:13  y:29   curvature:0
Q:72   P:77   R:82  index:77  x:12  y:29   curvature:0
Q:73   P:78   R:83  index:78  x:11  y:29   curvature:0
Q:74   P:79   R:84  index:79  x:10  y:29   curvature:0
Q:75   P:80   R:85  index:80  x:9   y:29   curvature:0.25
Q:76   P:81   R:86  index:81  x:8   y:29   curvature:0.666667
Q:77   P:82   R:87  index:82  x:7   y:29   curvature:1.5
Q:78   P:83   R:88  index:83  x:6   y:29   curvature:4
Q:79   P:84   R:89  index:84  x:5   y:29   curvature:5
Q:80   P:85   R:90  index:85  x:5   y:28   curvature:5
Q:81   P:86   R:91  index:86  x:5   y:27   curvature:5
Q:82   P:87   R:92  index:87  x:5   y:26   curvature:4
Q:83   P:88   R:93  index:88  x:5   y:25   curvature:1
Q:84   P:89   R:94  index:89  x:5   y:24   curvature:0
Q:85   P:90   R:95  index:90  x:5   y:23   curvature:0
Q:86   P:91   R:96  index:91  x:5   y:22   curvature:0
Q:87   P:92   R:97  index:92  x:5   y:21   curvature:0
Q:88   P:93   R:98  index:93  x:5   y:20   curvature:0
Q:89   P:94   R:99  index:94  x:5   y:19   curvature:0
Q:90   P:95   R:100 index:95  x:5   y:18   curvature:0
Q:91   P:96   R:101 index:96  x:5   y:17   curvature:0
Q:92   P:97   R:102 index:97  x:5   y:16   curvature:0
Q:93   P:98   R:103 index:98  x:5   y:15   curvature:0
Q:94   P:99   R:104 index:99  x:5   y:14   curvature:0
Q:95   P:100  R:105 index:100 x:5   y:13   curvature:0
Q:96   P:101  R:106 index:101 x:5   y:12   curvature:0
Q:97   P:102  R:107 index:102 x:5   y:11   curvature:0
Q:98   P:103  R:108 index:103 x:5   y:10   curvature:1
Q:99   P:104  R:0   index:104 x:5   y:9    curvature:1
Q:100  P:105  R:1   index:105 x:5   y:8    curvature:8
Q:101  P:106  R:2   index:106 x:5   y:7    curvature:6
Q:102  P:107  R:3   index:107 x:5   y:6    curvature:5.33333
```

```
Q:103  P:108  R:4 index:108 x:5  y:6  curvature:4.25
Q:104  P:0  R:5 index:0 x:5  y:5  curvature:4
Q:105  P:1  R:6 index:1 x:6  y:5  curvature:3
Q:106  P:2  R:7 index:2 x:7  y:5  curvature:1
Q:107  P:3  R:8 index:3 x:8  y:5  curvature:0
```

Output for Data D

```
x:5 y:15 corner:9 curve:5
x:6 y:14 corner:1 curve:3
x:7 y:13 corner:1 curve:1
x:8 y:12 corner:1 curve:0
x:9 y:11 corner:1 curve:0
x:10 y:10 corner:1 curve:0
x:11 y:9 corner:1 curve:0.2
x:12 y:8 corner:1 curve:0.4
x:13 y:7 corner:1 curve:0.6
x:14 y:6 corner:1 curve:0.8
x:15 y:5 corner:1 curve:1
x:16 y:5 corner:1 curve:0
x:17 y:5 corner:1 curve:0
x:18 y:5 corner:1 curve:0
x:19 y:5 corner:1 curve:0
x:20 y:5 corner:1 curve:0.2
x:21 y:5 corner:1 curve:0.4
x:22 y:5 corner:1 curve:0.6
x:23 y:5 corner:1 curve:0.8
x:24 y:5 corner:9 curve:1
x:25 y:6 corner:1 curve:1
x:26 y:7 corner:1 curve:1
x:27 y:8 corner:1 curve:1
x:28 y:9 corner:9 curve:1
x:29 y:10 corner:1 curve:0
x:30 y:11 corner:1 curve:0.25
x:31 y:12 corner:1 curve:0.666667
x:32 y:13 corner:1 curve:1.5
x:33 y:14 corner:1 curve:4
x:34 y:15 corner:1 curve:6
x:34 y:16 corner:1 curve:6
x:34 y:17 corner:1 curve:6
x:34 y:18 corner:1 curve:7
x:34 y:19 corner:1 curve:10
x:34 y:20 corner:1 curve:0
x:34 y:21 corner:1 curve:2.5
x:34 y:22 corner:1 curve:3.33333
x:34 y:23 corner:1 curve:3.75
x:34 y:24 corner:9 curve:4
x:33 y:25 corner:9 curve:4
x:32 y:26 corner:1 curve:1
x:31 y:27 corner:1 curve:0
x:30 y:28 corner:1 curve:0
x:29 y:29 corner:1 curve:0
```

```
x:28 y:30 corner:1 curve:0.2
x:27 y:31 corner:1 curve:0.4
x:26 y:32 corner:1 curve:0.6
x:25 y:33 corner:1 curve:0.8
x:24 y:34 corner:1 curve:1
x:23 y:34 corner:1 curve:0
x:22 y:34 corner:1 curve:0
x:21 y:34 corner:1 curve:0
x:20 y:34 corner:1 curve:0
x:19 y:34 corner:1 curve:0.2
x:18 y:34 corner:1 curve:0.4
x:17 y:34 corner:1 curve:0.6
x:16 y:34 corner:1 curve:0.8
x:15 y:34 corner:9 curve:1
x:14 y:33 corner:1 curve:1
x:13 y:32 corner:1 curve:1
x:12 y:31 corner:1 curve:1
x:11 y:30 corner:9 curve:1
x:10 y:29 corner:1 curve:0
x:9 y:28 corner:1 curve:0.25
x:8 y:27 corner:1 curve:0.666667
x:7 y:26 corner:1 curve:1.5
x:6 y:25 corner:9 curve:4
x:5 y:24 corner:1 curve:4
x:5 y:23 corner:1 curve:4
x:5 y:22 corner:9 curve:4
x:5 y:21 corner:1 curve:3
x:5 y:20 corner:1 curve:1
x:5 y:19 corner:1 curve:1
x:5 y:18 corner:1 curve:9
x:5 y:17 corner:1 curve:7
x:5 y:16 corner:1 curve:6.33333
x:5 y:16 corner:1 curve:5.25
```

```
5  15
6  14
7  13
8  12
9  11
10 10
11 9
12 8
13 7
14 6
15 5
16 5
17 5
18 5
19 5
20 5
21 5
22 5
23 5
24 5
25 6
26 7
27 8
28 9
29 10
30 11
31 12
32 13
33 14
34 15
34 16
34 17
34 18
34 19
34 20
34 21
34 22
34 23
34 24
33 25
32 26
31 27
30 28
29 29
28 30
27 31
26 32
25 33
24 34
23 34
22 34
21 34
```

```
20 34
19 34
18 34
17 34
16 34
15 34
14 33
13 32
12 31
11 30
10 29
9 28
8 27
7 26
6 25
5 24
5 23
5 22
5 21
5 20
5 19
5 18
5 17
5 16
5 16
Q:0   P:5   R:10 index:5  x:10  y:10  curvature:0
Q:1   P:6   R:11 index:6  x:11  y:9   curvature:0.2
Q:2   P:7   R:12 index:7  x:12  y:8   curvature:0.4
Q:3   P:8   R:13 index:8  x:13  y:7   curvature:0.6
Q:4   P:9   R:14 index:9  x:14  y:6   curvature:0.8
Q:5   P:10  R:15 index:10 x:15  y:5   curvature:1
Q:6   P:11  R:16 index:11 x:16  y:5   curvature:0
Q:7   P:12  R:17 index:12 x:17  y:5   curvature:0
Q:8   P:13  R:18 index:13 x:18  y:5   curvature:0
Q:9   P:14  R:19 index:14 x:19  y:5   curvature:0
Q:10  P:15  R:20 index:15 x:20  y:5   curvature:0.2
Q:11  P:16  R:21 index:16 x:21  y:5   curvature:0.4
Q:12  P:17  R:22 index:17 x:22  y:5   curvature:0.6
Q:13  P:18  R:23 index:18 x:23  y:5   curvature:0.8
Q:14  P:19  R:24 index:19 x:24  y:5   curvature:1
Q:15  P:20  R:25 index:20 x:25  y:6   curvature:1
Q:16  P:21  R:26 index:21 x:26  y:7   curvature:1
Q:17  P:22  R:27 index:22 x:27  y:8   curvature:1
Q:18  P:23  R:28 index:23 x:28  y:9   curvature:1
Q:19  P:24  R:29 index:24 x:29  y:10  curvature:0
Q:20  P:25  R:30 index:25 x:30  y:11  curvature:0.25
Q:21  P:26  R:31 index:26 x:31  y:12  curvature:0.666667
Q:22  P:27  R:32 index:27 x:32  y:13  curvature:1.5
Q:23  P:28  R:33 index:28 x:33  y:14  curvature:4
Q:24  P:29  R:34 index:29 x:34  y:15  curvature:6
Q:25  P:30  R:35 index:30 x:34  y:16  curvature:6
Q:26  P:31  R:36 index:31 x:34  y:17  curvature:6
Q:27  P:32  R:37 index:32 x:34  y:18  curvature:7
Q:28  P:33  R:38 index:33 x:34  y:19  curvature:10
```

```
Q:29  P:34  R:39 index:34 x:34  y:20  curvature:0
Q:30  P:35  R:40 index:35 x:34  y:21  curvature:2.5
Q:31  P:36  R:41 index:36 x:34  y:22  curvature:3.33333
Q:32  P:37  R:42 index:37 x:34  y:23  curvature:3.75
Q:33  P:38  R:43 index:38 x:34  y:24  curvature:4
Q:34  P:39  R:44 index:39 x:33  y:25  curvature:4
Q:35  P:40  R:45 index:40 x:32  y:26  curvature:1
Q:36  P:41  R:46 index:41 x:31  y:27  curvature:0
Q:37  P:42  R:47 index:42 x:30  y:28  curvature:0
Q:38  P:43  R:48 index:43 x:29  y:29  curvature:0
Q:39  P:44  R:49 index:44 x:28  y:30  curvature:0.2
Q:40  P:45  R:50 index:45 x:27  y:31  curvature:0.4
Q:41  P:46  R:51 index:46 x:26  y:32  curvature:0.6
Q:42  P:47  R:52 index:47 x:25  y:33  curvature:0.8
Q:43  P:48  R:53 index:48 x:24  y:34  curvature:1
Q:44  P:49  R:54 index:49 x:23  y:34  curvature:0
Q:45  P:50  R:55 index:50 x:22  y:34  curvature:0
Q:46  P:51  R:56 index:51 x:21  y:34  curvature:0
Q:47  P:52  R:57 index:52 x:20  y:34  curvature:0
Q:48  P:53  R:58 index:53 x:19  y:34  curvature:0.2
Q:49  P:54  R:59 index:54 x:18  y:34  curvature:0.4
Q:50  P:55  R:60 index:55 x:17  y:34  curvature:0.6
Q:51  P:56  R:61 index:56 x:16  y:34  curvature:0.8
Q:52  P:57  R:62 index:57 x:15  y:34  curvature:1
Q:53  P:58  R:63 index:58 x:14  y:33  curvature:1
Q:54  P:59  R:64 index:59 x:13  y:32  curvature:1
Q:55  P:60  R:65 index:60 x:12  y:31  curvature:1
Q:56  P:61  R:66 index:61 x:11  y:30  curvature:1
Q:57  P:62  R:67 index:62 x:10  y:29  curvature:0
Q:58  P:63  R:68 index:63 x:9  y:28  curvature:0.25
Q:59  P:64  R:69 index:64 x:8  y:27  curvature:0.666667
Q:60  P:65  R:70 index:65 x:7  y:26  curvature:1.5
Q:61  P:66  R:71 index:66 x:6  y:25  curvature:4
Q:62  P:67  R:72 index:67 x:5  y:24  curvature:4
Q:63  P:68  R:73 index:68 x:5  y:23  curvature:4
Q:64  P:69  R:74 index:69 x:5  y:22  curvature:4
Q:65  P:70  R:75 index:70 x:5  y:21  curvature:3
Q:66  P:71  R:76 index:71 x:5  y:20  curvature:1
Q:67  P:72  R:0 index:72 x:5  y:19  curvature:1
Q:68  P:73  R:1 index:73 x:5  y:18  curvature:9
Q:69  P:74  R:2 index:74 x:5  y:17  curvature:7
Q:70  P:75  R:3 index:75 x:5  y:16  curvature:6.33333
Q:71  P:76  R:4 index:76 x:5  y:16  curvature:5.25
Q:72  P:0  R:5 index:0 x:5  y:15  curvature:5
Q:73  P:1  R:6 index:1 x:6  y:14  curvature:3
Q:74  P:2  R:7 index:2 x:7  y:13  curvature:1
Q:75  P:3  R:8 index:3 x:8  y:12  curvature:0
```