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Algorithm Steps for the Project:

1. PointSet ← given, K ← given
2. Randomly Select K centroids from the data
3. Change ← 0
4. For each P in PointSet, compute the distance to each centroid
5. minLabel ← label for the centroid related to the minimum distance
6. if P.label != minLabel
7. P.label ← minLabel
8. Changes ++
9. End-if
10. Repeat 4 to 9 until all P are processed
11. If changes > 2:
12. Compute K centroids
13. End-if
14. Repeat 3 to 13 while change > 2

**Main.java**

import java.io.BufferedReader;

import java.io.BufferedWriter;

import java.io.FileReader;

import java.io.FileWriter;

public class Main {

    public static void main(String[] args){

        try{

            BufferedReader br = new BufferedReader(new FileReader(args[0]));

            int k = Integer.parseInt(args[1]);

            BufferedWriter bw1 = new BufferedWriter(new FileWriter(args[2]));

            BufferedWriter bw2 = new BufferedWriter(new FileWriter(args[3]));

            Kmean kmean = new Kmean(br, k);

            kmean.kMeansClustering(bw1, bw2);

            br.close();

            bw1.close();

            bw2.close();

        }catch(Exception e){

            System.out.println(e.getMessage());

        }

    }

}

**Point.java**

public class Point {

    public int label;

    public double distance;

    public double x;

    public double y;

    public Point(Double X, Double Y){

        label = 0;

        x = X;

        y = Y;

    }

    public void plot(int[][] array){

    }

}

**Kmeans.java**

import java.io.BufferedReader;

import java.io.BufferedWriter;

import java.util.Random;

import java.util.StringTokenizer;

public class Kmean{

    public int k, numPts, numRows, numCols, change;

    public int[][] displayArray;

    public Point[] pointSet;

    public Point[] kCentroidArray;

    public Kmean(BufferedReader br, int K){

        change = 0;

        k = K;

        try{

            StringTokenizer st = new StringTokenizer(br.readLine());

            numRows = Integer.parseInt(st.nextToken());

            numCols = Integer.parseInt(st.nextToken());

            st = new StringTokenizer(br.readLine());

            numPts = Integer.parseInt(st.nextToken());

            displayArray = new int[numRows][numCols];

            pointSet = new Point[numPts];

            kCentroidArray = new Point[k + 1];

            loadPointSet(br, st);

        }catch(Exception E){

            System.out.println(E.getMessage());

            System.exit(0);

        }

    }

    public void loadPointSet(BufferedReader br, StringTokenizer st){

        try{

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

                st = new StringTokenizer(br.readLine());

                pointSet[i] = new Point(Double.parseDouble(st.nextToken()), Double.parseDouble(st.nextToken()));

            }

        }catch(Exception E){

            System.out.println(E.getMessage());

            System.exit(0);

        }

    }

    public void kMeansClustering(BufferedWriter first, BufferedWriter second){

        int iter = 0, change, minLabel;

        selectKCentroids();

        do{

            change = 0;

            ++iter;

            plotDisplayArray();

            prettyPrint(first, iter);

            for(Point p : pointSet){

                minLabel = distanceMinLabel(p, p.distance);

                if (p.label != minLabel){

                    p.label = minLabel;

                    p.distance = computeDistance(p, p.label);

                    ++change;

                }

            }

            if(change >= 2) computeCentroids();

        }while(change > 2);

        try{

            second.write(Integer.toString(numRows) + " " + Integer.toString(numCols) + "\n");

            second.write(Integer.toString(numPts) + "\n");

            for(Point P : pointSet){

                second.write(Integer.toString((int)P.x) + " " + Integer.toString((int)P.y) + " " + Integer.toString((int)P.label) + "\n");

            }

        }catch(Exception E){

            System.out.println(E.getMessage());

            System.exit(0);

        }

    }

    public void selectKCentroids(){

        boolean[] arr = new boolean[numPts];

        Random rand = new Random();

        for(int i = 0; i < arr.length; ++i){

            arr[i] = true;

        }

        int index;

        for(int i = 1; i <= k; ++i){

            index = 0;

            do{

                index = rand.nextInt(numPts);

            }while(!arr[index]);

            kCentroidArray[i] = new Point(pointSet[index].x, pointSet[index].y);

            kCentroidArray[i].label = index;

            kCentroidArray[i].distance = 0;

            arr[index] = false;

        }

        for(Point p : pointSet){

            p.label = rand.nextInt(k) + 1;

            p.distance = computeDistance(p, p.label);

        }

    }

    public void computeCentroids(){

        double[] sumX = new double[k+1];

        double[] sumY = new double[k+1];

        int[] totalPt = new int[k+1];

        for(int i = 0; i <= k; ++i){

            sumX[i] = 0.0;

            sumY[i] = 0.0;

            totalPt[i] = 0;

        }

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

            sumX[pointSet[i].label] += pointSet[i].x;

            sumY[pointSet[i].label] += pointSet[i].y;

            totalPt[pointSet[i].label]++;

        }

        for(int i = 1; i <= k; ++i){

            if(totalPt[i] > 0){

                kCentroidArray[i].x = sumX[i] / totalPt[i];

                kCentroidArray[i].y = sumY[i] / totalPt[i];

            }

        }

    }

    public int distanceMinLabel(Point p, double minDist){

        int minLabel = p.label;

        double currDist = 0;

        for(int i = 1; i <= k; ++i){

            currDist = computeDistance(p, i);

            if (currDist < minDist){

                minDist = currDist;

                minLabel = i;

            }

        }

        return minLabel;

    }

    public double computeDistance(Point p, int centroidLabel){

        double dx = p.x - kCentroidArray[centroidLabel].x;

        double dy = p.y - kCentroidArray[centroidLabel].y;

        return Math.sqrt(dx\*dx + dy\*dy);

    }

    public void plotDisplayArray(){

        for(int i = 0; i < numRows; ++i){

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

                displayArray[i][j] = 0;

            }

        }

        int i = 0;

        int j = 0;

        for(Point p : pointSet){

            i =  (int)Math.floor(p.x);

            j = (int)Math.floor(p.y);

            displayArray[i][j] = p.label;

        }

    }

    public void prettyPrint(BufferedWriter bw, int iteration){

        try{

            char[] outp = new char[1];

            bw.write("Printing Iteration " + Integer.toString(iteration)+ " and k = " + Integer.toString(k) + "\n");

            for(int i = 0; i < numRows; ++i){

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

                    int value = 'A' - 1 + displayArray[i][j];

                    if (value < 'A') outp[0] = '.';

                    else outp[0] = (char)value;

                    bw.write(outp);

                    bw.write(" ");

                }

                bw.write("\n");

            }

        }catch(Exception E){

            System.out.println(E.getMessage());

            System.exit(0);

        }

    }

}

**ONE OUTPUT FOR EACH K = ( 3 | 4 | 5 )**

The rest of the outputs will be inside of the jar. This file will be to large with them all. Starts on the next page

Printing Iteration 1 and k = 3

............................................................

......AB....................................................

....A.......................................................

...B.ABABC..................................................

....ABB.B...................................................

...C.C.B....................................................

..BCCB..CAA..............AA.CA..............................

..B.AACBCBC.............C.AACAC.............................

..BBAB.A............C....B.CBC.BC...........................

...A..BACA...........A..BA.A.ACBCAA.........................

..CA.A.CB.A...........C..C.AA.CB.BA.CB......................

....AA.C.A..B.........AB...A..CACBC.........................

...BB.BB..CB.............A.B.C.B...................BAC......

.....CC.AC..............C.C.B.B.CC..........................

.......A.................CBAABC.CC...............CCC..BCA...

....AB...CA.............A.A.AB.BA..................ABA......

.......................A...C.BB.AC..................BBA.....

......................B...A.C.....................ABAC.ABB..

...............................C.................B...CBAC...

.............................................A.BCACCA.CBC...

...................................................CAAB.....

................................................CCC....AAC..

..................................................BABC......

.....................................................BACC...

..................................................CBBA......

.......................................................AAB..

..AAC..BB...........................................CBB.....

...A.ACCB...................................................

....A.AB.AAAB................BA.............................

..CB.ABAC....................AC.AA..B.......................

..BCAC.B..AC..............AB...BBB.C........................

.CBA.BB..BB...............CA.CC..AC.........................

..BA..AC.................BC.BC..BC..........................

...AAA.ACC................CC..AB.C..........................

.....CCA....................CAA.C..B........................

.CBC......................CC..CB.B...................B......

...CCA...................CBA.AAA.CCB................BBBB....

........................B.AB..CB..................B..BCCB...

.......................B.....ACA.ABA............B..BBBAB....

.....................C....BBBCBC.CCA.............ABC..CCCC..

................................A...............A..AABA.....

..........................BC.CAA...............B.B..C..CAAA.

............................AAB.ABA...............B..BBCA...

..........................AC..AA.................B..BACC....

............................................................

Printing Iteration 2 and k = 3

............................................................

......CC....................................................

....C.......................................................

...C.CCCCC..................................................

....CCC.C...................................................

...C.C.C....................................................

..CCCC..CCC..............CC.CC..............................

..C.CCCCCCC.............C.CCCCC.............................

..CCCC.C............C....C.CCC.CC...........................

...C..CCCC...........C..CC.C.CCCCCC.........................

..CC.C.CC.C...........C..C.CC.CC.CC.CC......................

....CC.C.C..C.........CC...C..CCCCC.........................

...CC.CC..CC.............C.C.C.C...................CCC......

.....CC.CC..............C.C.C.C.CC..........................

.......C.................CCCCCC.CC...............CCC..BBB...

....CC...CC.............C.C.CC.CC..................BBB......

.......................C...C.CC.CC..................BBB.....

......................C...C.C.....................BBBB.BBB..

...............................C.................B...BBBB...

.............................................C.BBBBBB.BBB...

...................................................BBBB.....

................................................BBB....BBB..

..................................................BBBB......

.....................................................BBBB...

..................................................BBBB......

.......................................................BBB..

..CCC..AA...........................................BBB.....

...A.AAAA...................................................

....A.AA.AAAA................AA.............................

..AA.AAAA....................AA.AA..A.......................

..AAAA.A..AA..............AA...AAA.A........................

.AAA.AA..AA...............AA.AA..AA.........................

..AA..AA.................AA.AA..AA..........................

...AAA.AAA................AA..AA.A..........................

.....AAA....................AAA.A..A........................

.AAA......................AA..AA.A...................B......

...AAA...................AAA.AAA.AAA................BBBB....

........................A.AA..AA..................B..BBBB...

.......................A.....AAA.AAA............B..BBBBB....

.....................A....AAAAAA.AAA.............BBB..BBBB..

................................A...............B..BBBB.....

..........................AA.AAA...............B.B..B..BBBB.

............................AAA.AAA...............B..BBBB...

..........................AA..AA.................B..BBBB....

............................................................

Printing Iteration 3 and k = 3

............................................................

......CC....................................................

....C.......................................................

...C.CCCCC..................................................

....CCC.C...................................................

...C.C.C....................................................

..CCCC..CCC..............CC.CC..............................

..C.CCCCCCC.............C.CCCCC.............................

..CCCC.C............C....C.CCC.CC...........................

...C..CCCC...........C..CC.C.CCCCCC.........................

..CC.C.CC.C...........C..C.CC.CC.CC.CC......................

....CC.C.C..C.........CC...C..CCCCC.........................

...CC.CC..CC.............C.C.C.C...................BBB......

.....CC.CC..............C.C.C.C.CC..........................

.......C.................CCCCCC.CC...............BBB..BBB...

....CC...CC.............C.C.CC.CC..................BBB......

.......................C...C.CC.CC..................BBB.....

......................C...C.C.....................BBBB.BBB..

...............................C.................B...BBBB...

.............................................B.BBBBBB.BBB...

...................................................BBBB.....

................................................BBB....BBB..

..................................................BBBB......

.....................................................BBBB...

..................................................BBBB......

.......................................................BBB..

..AAA..AA...........................................BBB.....

...A.AAAA...................................................

....A.AA.AAAA................AA.............................

..AA.AAAA....................AA.AA..A.......................

..AAAA.A..AA..............AA...AAA.A........................

.AAA.AA..AA...............AA.AA..AA.........................

..AA..AA.................AA.AA..AA..........................

...AAA.AAA................AA..AA.A..........................

.....AAA....................AAA.A..A........................

.AAA......................AA..AA.A...................B......

...AAA...................AAA.AAA.AAA................BBBB....

........................A.AA..AA..................B..BBBB...

.......................A.....AAA.AAA............B..BBBBB....

.....................A....AAAAAA.AAA.............BBB..BBBB..

................................A...............B..BBBB.....

..........................AA.AAA...............B.B..B..BBBB.

............................AAA.AAA...............B..BBBB...

..........................AA..AA.................B..BBBB....

............................................................

|  |  |  |
| --- | --- | --- |
| 45 60  399  41 56 2  41 57 2  42 29 1  42 30 1  1 6 3  2 4 3  3 3 3  3 7 3  3 8 3  34 30 1  34 32 1  34 35 1  35 1 1  41 58 2  42 28 1  35 2 1  35 3 1  35 26 1  3 9 3  6 3 3  7 2 3  4 4 3  1 7 3  4 5 3  39 51 2  39 54 2  39 55 2  39 56 2  39 57 2  40 32 1  40 48 2  20 53 2  20 54 2  21 48 2  21 49 2  40 51 2  40 52 2  41 26 1  41 27 1  41 29 1  4 6 3  4 8 3  5 3 3 | 5 5 3  3 5 3  3 6 3  5 7 3  6 2 3  40 53 2  40 54 2  7 4 3  7 5 3  6 4 3  6 5 3  6 8 3  6 9 3  6 10 3  6 25 3  6 29 3  7 6 3  7 7 3  6 26 3  6 28 3  7 8 3  7 9 3  7 10 3  16 53 2  16 54 2  17 22 3  17 26 3  8 20 3  8 25 3  8 27 3  9 9 3  9 21 3  11 27 3  11 30 3  11 31 3  11 32 3  9 24 3  9 25 3  9 33 3  9 34 3  10 2 3  10 3 3  10 5 3  10 7 3  10 8 3  10 10 3  10 22 3  10 25 3 | 10 27 3  9 27 3  9 29 3  9 30 3  9 31 3  9 32 3  10 28 3  10 30 3  10 31 3  10 33 3  10 34 3  10 36 3  10 37 3  11 4 3  11 5 3  11 7 3  11 9 3  11 12 3  11 22 3  11 23 3  11 33 3  11 34 3  12 3 3  12 4 3  12 6 3  12 7 3  12 10 3  12 11 3  12 25 3  12 27 3  12 29 3  12 31 3  12 51 2  12 52 2  12 53 2  13 5 3  13 6 3  13 8 3  13 9 3  13 24 3  17 28 3  17 50 2  8 7 3  13 32 3  13 33 3  14 7 3  14 25 3  14 26 3 |

|  |  |  |
| --- | --- | --- |
| 14 27 3  14 28 3  14 29 3  14 30 3  7 24 3  7 26 3  7 27 3  7 28 3  14 32 3  14 33 3  14 49 2  14 50 2  14 51 2  14 54 2  14 55 2  14 56 2  15 4 3  15 5 3  15 9 3  15 10 3  15 24 3  15 26 3  15 28 3  15 29 3  15 31 3  15 32 3  15 51 2  15 52 2  15 53 2  16 23 3  16 27 3  16 29 3  16 30 3  42 56 2  43 26 1  43 27 1  7 29 3  7 30 3  8 2 3  8 3 3  8 4 3  8 5 3  43 30 1  43 31 1  16 32 3  16 33 3  16 52 2 | 13 26 3  13 28 3  13 30 3  17 51 2  17 52 2  17 53 2  17 55 2  39 34 1  39 35 1  39 49 2  39 50 2  18 53 2  18 54 2  18 55 2  18 56 2  19 45 2  19 47 2  19 48 2  19 49 2  19 50 2  19 51 2  19 52 2  19 54 2  19 55 2  19 56 2  20 51 2  20 52 2  21 50 2  21 55 2  21 56 2  24 51 2  24 52 2  24 53 2  25 55 2  25 56 2  25 57 2  26 2 1  26 3 1  26 4 1  26 7 1  26 8 1  26 52 2  26 53 2  26 54 2  27 3 1  27 5 1  27 6 1  27 7 1 | 27 8 1  39 30 1  39 31 1  39 33 1  41 30 1  41 31 1  41 47 2  28 4 1  28 6 1  28 7 1  28 9 1  28 10 1  28 11 1  28 12 1  28 29 1  28 30 1  29 2 1  29 3 1  29 5 1  29 6 1  29 7 1  29 8 1  29 29 1  29 30 1  29 32 1  29 33 1  29 36 1  30 2 1  30 3 1  30 4 1  30 5 1  30 7 1  30 10 1  30 11 1  30 26 1  30 27 1  38 35 1  38 48 2  38 51 2  38 52 2  31 6 1  31 9 1  31 10 1  31 26 1  31 27 1  31 29 1  31 30 1  31 33 1 |

|  |  |  |
| --- | --- | --- |
| 31 34 1  32 2 1  32 3 1  32 6 1  32 7 1  32 25 1  32 26 1  32 28 1  32 29 1  32 32 1  32 33 1  33 3 1  33 4 1  33 5 1  33 7 1  33 8 1  33 9 1  33 26 1  33 27 1  33 30 1  33 31 1  33 33 1  34 5 1  34 6 1  34 7 1  34 28 1  34 29 1  35 27 1  35 30 1  35 31 1  35 33 1  35 53 2  36 3 1  36 4 1  36 5 1  36 25 1  36 26 1  36 27 1  17 56 2  17 57 2  18 31 3  18 49 2  36 29 1  36 30 1  36 31 1  36 52 2  36 53 2 | 36 54 2  36 55 2  37 24 1  37 26 1  37 27 1  37 30 1  37 31 1  37 50 2  37 53 2  37 54 2  37 55 2  37 56 2  38 23 1  38 29 1  38 30 1  36 33 1  36 34 1  36 35 1  38 31 1  38 33 1  38 34 1  38 53 2  38 54 2  38 55 2  39 21 1  39 26 1  39 27 1  39 28 1  39 29 1  41 49 2  41 52 2  41 55 2  42 32 1  42 54 2  42 55 2  30 31 1  30 32 1  30 33 1  30 35 1  31 1 1  31 2 1  42 33 1  42 34 1  42 50 2  42 53 2  31 3 1  31 5 1  43 49 2 | 43 52 2  43 53 2  8 28 3  8 29 3  8 31 3  8 32 3  9 3 3  9 6 3  9 7 3  9 8 3  43 54 2  43 55 2  21 57 2  22 50 2  22 51 2  22 52 2  22 53 2  23 53 2  23 54 2  23 55 2  23 56 2  24 50 2 |

Printing Iteration 1 and k = 4

............................................................

......AD....................................................

....C.......................................................

...B.DCADA..................................................

....DBB.B...................................................

...D.B.B....................................................

..CDDC..CBC..............AA.CA..............................

..A.BDCCDCA.............C.BDBBB.............................

..CABB.B............B....A.ABA.BA...........................

...C..BAAD...........B..BD.C.CDADDA.........................

..AB.B.CD.C...........B..C.DC.CA.CB.BA......................

....CC.D.A..C.........AC...B..BBBCB.........................

...AB.CC..BC.............C.A.D.B...................BBC......

.....BD.DA..............C.D.A.C.DA..........................

.......A.................AAACCA.BA...............AAC..CBB...

....DD...CD.............B.B.BA.DA..................DBB......

.......................A...C.BA.DA..................BBD.....

......................C...B.A.....................CCCB.BCA..

...............................D.................A...BCBD...

.............................................D.CADCAC.ACC...

...................................................DACA.....

................................................DDB....CBA..

..................................................CADA......

.....................................................CADC...

..................................................BDCB......

.......................................................BDD..

..BBC..CA...........................................CCA.....

...B.DCBC...................................................

....D.AD.CCCA................BC.............................

..BC.BACD....................AC.AB..A.......................

..AADB.B..AB..............DC...CDC.A........................

.BAC.DD..DD...............CA.DB..DA.........................

..BC..CC.................CD.DA..AC..........................

...BBD.CCB................AC..BD.C..........................

.....ADB....................CDC.A..C........................

.CCD......................AA..CB.D...................C......

...CAA...................ACA.CDD.CAB................CACD....

........................C.BB..DB..................D..CBBC...

.......................B.....BDC.ADD............B..CBBCB....

.....................C....BCBABD.AAB.............BAA..BDAB..

................................D...............B..CCBB.....

..........................AA.CCD...............D.A..C..CCCC.

............................BBD.BDD...............D..DDDA...

..........................AA..DC.................D..BDDC....

............................................................

Printing Iteration 2 and k = 4

............................................................

......DD....................................................

....D.......................................................

...D.DDDDD..................................................

....DDD.D...................................................

...D.D.D....................................................

..ADDD..DDD..............DD.DD..............................

..A.AADDDDD.............D.DDDDB.............................

..AAAA.A............D....D.DDB.BB...........................

...A..AAAA...........D..DD.D.BBBBBB.........................

..AA.A.AA.A...........D..D.BB.BB.BB.BB......................

....AA.A.A..A.........DD...B..BBBBB.........................

...AA.AA..AA.............B.B.B.B...................BBB......

.....AA.AA..............B.B.B.B.BB..........................

.......A.................BBBBBB.BB...............BBB..BBB...

....AA...AA.............B.B.BB.BB..................BBB......

.......................B...B.BB.BB..................BBB.....

......................B...B.B.....................BBBB.BBB..

...............................B.................B...BBBB...

.............................................B.BBBBBB.BBB...

...................................................BBBB.....

................................................BBB....BBB..

..................................................BBBB......

.....................................................BBBB...

..................................................BBBB......

.......................................................BBB..

..CCC..CC...........................................BBB.....

...C.CCCC...................................................

....C.CC.CCCC................BB.............................

..CC.CCCC....................BB.BB..B.......................

..CCCC.C..CC..............BB...BBB.B........................

.CCC.CC..CC...............BB.BB..BB.........................

..CC..CC.................BB.BB..BB..........................

...CCC.CCC................BB..BB.B..........................

.....CCC....................BBB.B..B........................

.CCC......................BB..BB.B...................B......

...CCC...................BBB.BBB.BBB................BBBB....

........................B.BB..BB..................B..BBBB...

.......................B.....BBB.BBB............B..BBBBB....

.....................B....BBBBBB.BBB.............BBB..BBBB..

................................B...............B..BBBB.....

..........................BB.BBB...............B.B..B..BBBB.

............................BBB.BBB...............B..BBBB...

..........................BB..BB.................B..BBBB....

............................................................

Printing Iteration 3 and k = 4

............................................................

......DD....................................................

....D.......................................................

...D.DDDDD..................................................

....DDD.D...................................................

...D.D.D....................................................

..ADDD..DDD..............DD.DD..............................

..A.AAAAADD.............D.DDDDD.............................

..AAAA.A............D....D.DDD.DD...........................

...A..AAAA...........D..DD.D.DDDDDB.........................

..AA.A.AA.A...........D..D.DD.DD.BB.BB......................

....AA.A.A..D.........DD...D..DDBBB.........................

...AA.AA..AA.............D.D.D.B...................BBB......

.....AA.AA..............D.D.D.D.BB..........................

.......A.................DDDDBB.BB...............BBB..BBB...

....AA...AA.............D.D.BB.BB..................BBB......

.......................D...B.BB.BB..................BBB.....

......................D...B.B.....................BBBB.BBB..

...............................B.................B...BBBB...

.............................................B.BBBBBB.BBB...

...................................................BBBB.....

................................................BBB....BBB..

..................................................BBBB......

.....................................................BBBB...

..................................................BBBB......

.......................................................BBB..

..CCC..CC...........................................BBB.....

...C.CCCC...................................................

....C.CC.CCCC................BB.............................

..CC.CCCC....................BB.BB..B.......................

..CCCC.C..CC..............BB...BBB.B........................

.CCC.CC..CC...............BB.BB..BB.........................

..CC..CC.................BB.BB..BB..........................

...CCC.CCC................BB..BB.B..........................

.....CCC....................BBB.B..B........................

.CCC......................BB..BB.B...................B......

...CCC...................BBB.BBB.BBB................BBBB....

........................B.BB..BB..................B..BBBB...

.......................B.....BBB.BBB............B..BBBBB....

.....................B....BBBBBB.BBB.............BBB..BBBB..

................................B...............B..BBBB.....

..........................BB.BBB...............B.B..B..BBBB.

............................BBB.BBB...............B..BBBB...

..........................BB..BB.................B..BBBB....

............................................................

Printing Iteration 4 and k = 4

............................................................

......DD....................................................

....D.......................................................

...D.DDDDD..................................................

....DDD.D...................................................

...D.D.D....................................................

..ADDD..DDD..............DD.DD..............................

..A.AAAAADD.............D.DDDDD.............................

..AAAA.A............D....D.DDD.DD...........................

...A..AAAA...........D..DD.D.DDDDDD.........................

..AA.A.AA.A...........D..D.DD.DD.DD.DD......................

....AA.A.A..D.........DD...D..DDDDD.........................

...AA.AA..AA.............D.D.D.D...................BBB......

.....AA.AA..............D.D.D.D.DD..........................

.......A.................DDDDDD.DD...............BBB..BBB...

....AA...AA.............D.D.DD.DD..................BBB......

.......................D...D.DD.DD..................BBB.....

......................D...D.D.....................BBBB.BBB..

...............................B.................B...BBBB...

.............................................B.BBBBBB.BBB...

...................................................BBBB.....

................................................BBB....BBB..

..................................................BBBB......

.....................................................BBBB...

..................................................BBBB......

.......................................................BBB..

..CCC..CC...........................................BBB.....

...C.CCCC...................................................

....C.CC.CCCC................BB.............................

..CC.CCCC....................BB.BB..B.......................

..CCCC.C..CC..............BB...BBB.B........................

.CCC.CC..CC...............BB.BB..BB.........................

..CC..CC.................BB.BB..BB..........................

...CCC.CCC................BB..BB.B..........................

.....CCC....................BBB.B..B........................

.CCC......................BB..BB.B...................B......

...CCC...................BBB.BBB.BBB................BBBB....

........................B.BB..BB..................B..BBBB...

.......................B.....BBB.BBB............B..BBBBB....

.....................B....BBBBBB.BBB.............BBB..BBBB..

................................B...............B..BBBB.....

..........................BB.BBB...............B.B..B..BBBB.

............................BBB.BBB...............B..BBBB...

..........................BB..BB.................B..BBBB....

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| --- | --- | --- |
| 45 60  399  41 56 2  41 57 2  42 29 2  42 30 2  1 6 4  2 4 4  3 3 4  3 7 4  3 8 4  34 30 2  34 32 2  34 35 2  35 1 3  41 58 2  42 28 2  35 2 3  35 3 3  35 26 2  3 9 4  6 3 4  7 2 1  4 4 4  1 7 4  4 5 4  39 51 2  39 54 2  39 55 2  39 56 2  39 57 2  40 32 2  40 48 2  20 53 2  20 54 2  21 48 2  21 49 2  40 51 2  40 52 2  41 26 2  41 27 2  41 29 2  4 6 4  4 8 4  5 3 4  5 5 4  3 5 4  3 6 4 | 5 7 4  6 2 1  40 53 2  40 54 2  7 4 1  7 5 1  6 4 4  6 5 4  6 8 4  6 9 4  6 10 4  6 25 4  6 29 4  7 6 1  7 7 1  6 26 4  6 28 4  7 8 1  7 9 4  7 10 4  16 53 2  16 54 2  17 22 4  17 26 4  8 20 4  8 25 4  8 27 4  9 9 1  9 21 4  11 27 4  11 30 4  11 31 4  11 32 4  9 24 4  9 25 4  9 33 4  9 34 4  10 2 1  10 3 1  10 5 1  10 7 1  10 8 1  10 10 1  10 22 4  10 25 4  10 27 4  9 27 4  9 29 4 | 9 30 4  9 31 4  9 32 4  10 28 4  10 30 4  10 31 4  10 33 4  10 34 4  10 36 4  10 37 4  11 4 1  11 5 1  11 7 1  11 9 1  11 12 4  11 22 4  11 23 4  11 33 4  11 34 4  12 3 1  12 4 1  12 6 1  12 7 1  12 10 1  12 11 1  12 25 4  12 27 4  12 29 4  12 31 4  12 51 2  12 52 2  12 53 2  13 5 1  13 6 1  13 8 1  13 9 1  13 24 4  17 28 4  17 50 2  8 7 1  13 32 4  13 33 4  14 7 1  14 25 4  14 26 4  14 27 4  14 28 4  14 29 4 |

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| --- | --- | --- |
| 14 30 4  7 24 4  7 26 4  7 27 4  7 28 4  14 32 4  14 33 4  14 49 2  14 50 2  14 51 2  14 54 2  14 55 2  14 56 2  15 4 1  15 5 1  15 9 1  15 10 1  15 24 4  15 26 4  15 28 4  15 29 4  15 31 4  15 32 4  15 51 2  15 52 2  15 53 2  16 23 4  16 27 4  16 29 4  16 30 4  42 56 2  43 26 2  43 27 2  7 29 4  7 30 4  8 2 1  8 3 1  8 4 1  8 5 1  43 30 2  43 31 2  16 32 4  16 33 4  16 52 2  13 26 4  13 28 4  13 30 4  17 51 2  17 52 2 | 17 53 2  17 55 2  39 34 2  39 35 2  39 49 2  39 50 2  18 53 2  18 54 2  18 55 2  18 56 2  19 45 2  19 47 2  19 48 2  19 49 2  19 50 2  19 51 2  19 52 2  19 54 2  19 55 2  19 56 2  20 51 2  20 52 2  21 50 2  21 55 2  21 56 2  24 51 2  24 52 2  24 53 2  25 55 2  25 56 2  25 57 2  26 2 3  26 3 3  26 4 3  26 7 3  26 8 3  26 52 2  26 53 2  26 54 2  27 3 3  27 5 3  27 6 3  27 7 3  27 8 3  39 30 2  39 31 2  39 33 2  41 30 2 | 41 31 2  41 47 2  28 4 3  28 6 3  28 7 3  28 9 3  28 10 3  28 11 3  28 12 3  28 29 2  28 30 2  29 2 3  29 3 3  29 5 3  29 6 3  29 7 3  29 8 3  29 29 2  29 30 2  29 32 2  29 33 2  29 36 2  30 2 3  30 3 3  30 4 3  30 5 3  30 7 3  30 10 3  30 11 3  30 26 2  30 27 2  38 35 2  38 48 2  38 51 2  38 52 2  31 6 3  31 9 3  31 10 3  31 26 2  31 27 2  31 29 2  31 30 2  31 33 2  31 34 2  32 2 3  32 3 3  32 6 3  32 7 3 |

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| --- | --- | --- |
| 32 25 2  32 26 2  32 28 2  32 29 2  32 32 2  32 33 2  33 3 3  33 4 3  33 5 3  33 7 3  33 8 3  33 9 3  33 26 2  33 27 2  33 30 2  33 31 2  33 33 2  34 5 3  34 6 3  34 7 3  34 28 2  34 29 2  35 27 2  35 30 2  35 31 2  35 33 2  35 53 2  36 3 3  36 4 3  36 5 3  36 25 2  36 26 2  36 27 2  17 56 2  17 57 2  18 31 4  18 49 2  36 29 2  36 30 2  36 31 2  36 52 2  36 53 2  36 54 2  36 55 2  37 24 2  37 26 2  37 27 2  37 30 2  37 31 2 | 37 50 2  37 53 2  37 54 2  37 55 2  37 56 2  38 23 2  38 29 2  38 30 2  36 33 2  36 34 2  36 35 2  38 31 2  38 33 2  38 34 2  38 53 2  38 54 2  38 55 2  39 21 2  39 26 2  39 27 2  39 28 2  39 29 2  41 49 2  41 52 2  41 55 2  42 32 2  42 54 2  42 55 2  30 31 2  30 32 2  30 33 2  30 35 2  31 1 3  31 2 3  42 33 2  42 34 2  42 50 2  42 53 2  31 3 3  31 5 3  43 49 2  43 52 2  43 53 2  8 28 4  8 29 4  8 31 4  8 32 4  9 3 1 | 9 6 1  9 7 1  9 8 1  43 54 2  43 55 2  21 57 2  22 50 2  22 51 2  22 52 2  22 53 2  23 53 2  23 54 2  23 55 2  23 56 2  24 50 2 |

Printing Iteration 1 and k = 5

............................................................

......AA....................................................

....E.......................................................

...C.DDEBA..................................................

....ADD.B...................................................

...C.D.A....................................................

..CCCB..BED..............AB.BC..............................

..D.AAABBAE.............B.ADAAD.............................

..CEBD.C............C....B.CAC.BE...........................

...E..AEEE...........B..DD.E.BBCCAC.........................

..AC.C.EB.E...........B..D.CA.CA.AD.EA......................

....AE.E.A..C.........EE...B..EDECC.........................

...AD.EB..AA.............B.E.B.D...................ACC......

.....CA.AD..............A.B.C.D.ED..........................

.......A.................CEAABE.CA...............CBE..AAB...

....DD...AA.............E.C.DE.ED..................CAB......

.......................A...A.BC.CC..................BCD.....

......................E...D.A.....................DDDB.CAD..

...............................C.................A...BDBC...

.............................................D.EAACCA.BBC...

...................................................CDBC.....

................................................EEA....BED..

..................................................ADDB......

.....................................................CDEA...

..................................................EDDC......

.......................................................BCD..

..DDD..DA...........................................ACE.....

...A.BBAD...................................................

....B.EA.DCAA................AC.............................

..CE.DEDE....................CD.BB..A.......................

..EDAA.B..BA..............EE...ABA.A........................

.CEA.AC..BE...............DB.CA..DA.........................

..ED..AD.................EC.CA..BB..........................

...ECA.BEA................DB..AD.E..........................

.....ADA....................DAE.D..A........................

.DDE......................DE..CA.A...................E......

...AAE...................EBD.DAC.EBD................DBCC....

........................A.BC..CC..................C..ECBC...

.......................A.....ECD.DEE............A..DBABA....

.....................C....EADBBC.BEB.............ADB..BECA..

................................B...............B..EAAE.....

..........................AC.DCC...............E.D..E..BADD.

............................BDC.DAA...............E..DBDE...

..........................DD..EA.................D..BEAA....

............................................................

Printing Iteration 2 and k = 5

............................................................

......BB....................................................

....B.......................................................

...B.BBBBB..................................................

....BBB.B...................................................

...B.B.B....................................................

..BBBB..BBB..............DD.CC..............................

..B.BBBBBBB.............D.DCCCC.............................

..BBBB.B............D....D.CCC.CC...........................

...B..BBBB...........D..DD.C.CCCCCC.........................

..BB.B.BB.B...........D..C.CC.CC.CC.CC......................

....BB.B.B..B.........DD...C..CCCCC.........................

...BB.BB..BB.............C.C.C.C...................CCC......

.....BB.BB..............C.C.C.C.CC..........................

.......B.................CCCCCC.CC...............CCC..CCC...

....BB...BB.............C.C.CC.CC..................CCC......

.......................C...C.CC.CC..................CCC.....

......................C...C.C.....................CCCC.CCC..

...............................C.................C...CCCC...

.............................................C.CCCCCC.CCC...

...................................................CCCC.....

................................................AAA....AAA..

..................................................AAAA......

.....................................................AAAA...

..................................................AAAA......

.......................................................AAA..

..EEE..EE...........................................AAA.....

...E.EEEE...................................................

....E.EE.EEEE................AA.............................

..EE.EEEE....................AA.AA..A.......................

..EEEE.E..EE..............AA...AAA.A........................

.EEE.EE..EE...............AA.AA..AA.........................

..EE..EE.................AA.AA..AA..........................

...EEE.EEE................AA..AA.A..........................

.....EEE....................AAA.A..A........................

.EEE......................AA..AA.A...................A......

...EEE...................AAA.AAA.AAA................AAAA....

........................A.AA..AA..................A..AAAA...

.......................A.....AAA.AAA............A..AAAAA....

.....................A....AAAAAA.AAA.............AAA..AAAA..

................................A...............A..AAAA.....

..........................AA.AAA...............A.A..A..AAAA.

............................AAA.AAA...............A..AAAA...

..........................AA..AA.................A..AAAA....

............................................................

Printing Iteration 3 and k = 5

............................................................

......BB....................................................

....B.......................................................

...B.BBBBB..................................................

....BBB.B...................................................

...B.B.B....................................................

..BBBB..BBB..............DD.CC..............................

..B.BBBBBBB.............D.DCCCC.............................

..BBBB.B............D....D.CCC.CC...........................

...B..BBBB...........D..DD.C.CCCCCC.........................

..BB.B.BB.B...........D..D.CC.CC.CC.CC......................

....BB.B.B..B.........DD...C..CCCCC.........................

...BB.BB..BB.............D.C.C.C...................CCC......

.....BB.BB..............D.D.C.C.CC..........................

.......B.................DDCCCC.CC...............CCC..CCC...

....BB...BB.............D.D.CC.CC..................CCC......

.......................D...C.CC.CC..................CCC.....

......................D...D.C.....................CCCC.CCC..

...............................C.................C...CCCC...

.............................................C.CCCCCC.CCC...

...................................................CCCC.....

................................................CCC....CCC..

..................................................CCCC......

.....................................................AAAA...

..................................................AAAA......

.......................................................AAA..

..EEE..EE...........................................AAA.....

...E.EEEE...................................................

....E.EE.EEEE................AA.............................

..EE.EEEE....................AA.AA..A.......................

..EEEE.E..EE..............AA...AAA.A........................

.EEE.EE..EE...............AA.AA..AA.........................

..EE..EE.................AA.AA..AA..........................

...EEE.EEE................AA..AA.A..........................

.....EEE....................AAA.A..A........................

.EEE......................AA..AA.A...................A......

...EEE...................AAA.AAA.AAA................AAAA....

........................A.AA..AA..................A..AAAA...

.......................A.....AAA.AAA............A..AAAAA....

.....................A....AAAAAA.AAA.............AAA..AAAA..

................................A...............A..AAAA.....

..........................AA.AAA...............A.A..A..AAAA.

............................AAA.AAA...............A..AAAA...

..........................AA..AA.................A..AAAA....

............................................................

Printing Iteration 4 and k = 5

............................................................

......BB....................................................

....B.......................................................

...B.BBBBB..................................................

....BBB.B...................................................

...B.B.B....................................................

..BBBB..BBB..............DD.CC..............................

..B.BBBBBBB.............D.DCCCC.............................

..BBBB.B............D....D.CCC.CC...........................

...B..BBBB...........D..DD.C.CCCCCC.........................

..BB.B.BB.B...........D..D.CC.CC.CC.CC......................

....BB.B.B..B.........DD...D..CCCCC.........................

...BB.BB..BB.............D.D.C.C...................CCC......

.....BB.BB..............D.D.D.C.CC..........................

.......B.................DDDDDC.CC...............CCC..CCC...

....BB...BB.............D.D.DD.CC..................CCC......

.......................D...D.DD.CC..................CCC.....

......................D...D.D.....................CCCC.CCC..

...............................D.................C...CCCC...

.............................................C.CCCCCC.CCC...

...................................................CCCC.....

................................................CCC....CCC..

..................................................CCCC......

.....................................................CCCC...

..................................................CCCC......

.......................................................CCC..

..EEE..EE...........................................ACC.....

...E.EEEE...................................................

....E.EE.EEEE................AA.............................

..EE.EEEE....................AA.AA..A.......................

..EEEE.E..EE..............AA...AAA.A........................

.EEE.EE..EE...............AA.AA..AA.........................

..EE..EE.................AA.AA..AA..........................

...EEE.EEE................AA..AA.A..........................

.....EEE....................AAA.A..A........................

.EEE......................AA..AA.A...................A......

...EEE...................AAA.AAA.AAA................AAAA....

........................A.AA..AA..................A..AAAA...

.......................A.....AAA.AAA............A..AAAAA....

.....................A....AAAAAA.AAA.............AAA..AAAA..

................................A...............A..AAAA.....

..........................AA.AAA...............A.A..A..AAAA.

............................AAA.AAA...............A..AAAA...

..........................AA..AA.................A..AAAA....

............................................................

Printing Iteration 5 and k = 5

............................................................

......BB....................................................

....B.......................................................

...B.BBBBB..................................................

....BBB.B...................................................

...B.B.B....................................................

..BBBB..BBB..............DD.CC..............................

..B.BBBBBBB.............D.DCCCC.............................

..BBBB.B............D....D.CCC.CC...........................

...B..BBBB...........D..DD.C.CCCCCC.........................

..BB.B.BB.B...........D..D.CC.CC.CC.CC......................

....BB.B.B..B.........DD...D..CCCCC.........................

...BB.BB..BB.............D.D.D.C...................CCC......

.....BB.BB..............D.D.D.D.DC..........................

.......B.................DDDDDD.DD...............CCC..CCC...

....BB...BB.............D.D.DD.DD..................CCC......

.......................D...D.DD.DD..................CCC.....

......................D...D.D.....................CCCC.CCC..

...............................D.................C...CCCC...

.............................................C.CCCCCC.CCC...

...................................................CCCC.....

................................................CCC....CCC..

..................................................CCCC......

.....................................................CCCC...

..................................................CCCC......

.......................................................CCC..

..EEE..EE...........................................CCC.....

...E.EEEE...................................................

....E.EE.EEEE................AA.............................

..EE.EEEE....................AA.AA..A.......................

..EEEE.E..EE..............AA...AAA.A........................

.EEE.EE..EE...............AA.AA..AA.........................

..EE..EE.................AA.AA..AA..........................

...EEE.EEE................AA..AA.A..........................

.....EEE....................AAA.A..A........................

.EEE......................AA..AA.A...................A......

...EEE...................AAA.AAA.AAA................AAAA....

........................A.AA..AA..................A..AAAA...

.......................A.....AAA.AAA............A..AAAAA....

.....................A....AAAAAA.AAA.............AAA..AAAA..

................................A...............A..AAAA.....

..........................AA.AAA...............A.A..A..AAAA.

............................AAA.AAA...............A..AAAA...

..........................AA..AA.................A..AAAA....

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Printing Iteration 6 and k = 5

............................................................

......BB....................................................

....B.......................................................

...B.BBBBB..................................................

....BBB.B...................................................

...B.B.B....................................................

..BBBB..BBB..............DD.CC..............................

..B.BBBBBBB.............D.DCCCC.............................

..BBBB.B............D....D.CCC.CC...........................

...B..BBBB...........D..DD.C.CCCCCC.........................

..BB.B.BB.B...........D..D.CC.CC.CC.CC......................

....BB.B.B..B.........DD...D..DCCCC.........................

...BB.BB..BB.............D.D.D.D...................CCC......

.....BB.BB..............D.D.D.D.DD..........................

.......B.................DDDDDD.DD...............CCC..CCC...

....BB...BB.............D.D.DD.DD..................CCC......

.......................D...D.DD.DD..................CCC.....

......................D...D.D.....................CCCC.CCC..

...............................D.................C...CCCC...

.............................................C.CCCCCC.CCC...

...................................................CCCC.....

................................................CCC....CCC..

..................................................CCCC......

.....................................................CCCC...

..................................................CCCC......

.......................................................CCC..

..EEE..EE...........................................CCC.....

...E.EEEE...................................................

....E.EE.EEEE................AA.............................

..EE.EEEE....................AA.AA..A.......................

..EEEE.E..EE..............AA...AAA.A........................

.EEE.EE..EE...............AA.AA..AA.........................

..EE..EE.................AA.AA..AA..........................

...EEE.EEE................AA..AA.A..........................

.....EEE....................AAA.A..A........................

.EEE......................AA..AA.A...................A......

...EEE...................AAA.AAA.AAA................AAAA....

........................A.AA..AA..................A..AAAA...

.......................A.....AAA.AAA............A..AAAAA....

.....................A....AAAAAA.AAA.............AAA..AAAA..

................................A...............A..AAAA.....

..........................AA.AAA...............A.A..A..AAAA.

............................AAA.AAA...............A..AAAA...

..........................AA..AA.................A..AAAA....

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| 45 60  399  41 56 1  41 57 1  42 29 1  42 30 1  1 6 2  2 4 2  3 3 2  3 7 2  3 8 2  34 30 1  34 32 1  34 35 1  35 1 5  41 58 1  42 28 1  35 2 5  35 3 5  35 26 1  3 9 2  6 3 2  7 2 2  4 4 2  1 7 2  4 5 2  39 51 1  39 54 1  39 55 1  39 56 1  39 57 1  40 32 1  40 48 1  20 53 3  20 54 3  21 48 3  21 49 3  40 51 1  40 52 1  41 26 1  41 27 1  41 29 1  4 6 2  4 8 2  5 3 2  5 5 2  3 5 2  3 6 2  5 7 2  6 2 2 | 40 53 1  40 54 1  7 4 2  7 5 2  6 4 2  6 5 2  6 8 2  6 9 2  6 10 2  6 25 4  6 29 3  7 6 2  7 7 2  6 26 4  6 28 3  7 8 2  7 9 2  7 10 2  16 53 3  16 54 3  17 22 4  17 26 4  8 20 4  8 25 4  8 27 3  9 9 2  9 21 4  11 27 4  11 30 4  11 31 4  11 32 3  9 24 4  9 25 4  9 33 3  9 34 3  10 2 2  10 3 2  10 5 2  10 7 2  10 8 2  10 10 2  10 22 4  10 25 4  10 27 3  9 27 3  9 29 3  9 30 3  9 31 3 | 9 32 3  10 28 3  10 30 3  10 31 3  10 33 3  10 34 3  10 36 3  10 37 3  11 4 2  11 5 2  11 7 2  11 9 2  11 12 2  11 22 4  11 23 4  11 33 3  11 34 3  12 3 2  12 4 2  12 6 2  12 7 2  12 10 2  12 11 2  12 25 4  12 27 4  12 29 4  12 31 4  12 51 3  12 52 3  12 53 3  13 5 2  13 6 2  13 8 2  13 9 2  13 24 4  17 28 4  17 50 3  8 7 2  13 32 4  13 33 4  14 7 2  14 25 4  14 26 4  14 27 4  14 28 4  14 29 4  14 30 4  7 24 4 |

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| --- | --- | --- |
| 7 26 4  7 27 3  7 28 3  14 32 4  14 33 4  14 49 3  14 50 3  14 51 3  14 54 3  14 55 3  14 56 3  15 4 2  15 5 2  15 9 2  15 10 2  15 24 4  15 26 4  15 28 4  15 29 4  15 31 4  15 32 4  15 51 3  15 52 3  15 53 3  16 23 4  16 27 4  16 29 4  16 30 4  42 56 1  43 26 1  43 27 1  7 29 3  7 30 3  8 2 2  8 3 2  8 4 2  8 5 2  43 30 1  43 31 1  16 32 4  16 33 4  16 52 3  13 26 4  13 28 4  13 30 4  17 51 3  17 52 3  17 53 3  17 55 3 | 39 34 1  39 35 1  39 49 1  39 50 1  18 53 3  18 54 3  18 55 3  18 56 3  19 45 3  19 47 3  19 48 3  19 49 3  19 50 3  19 51 3  19 52 3  19 54 3  19 55 3  19 56 3  20 51 3  20 52 3  21 50 3  21 55 3  21 56 3  24 51 3  24 52 3  24 53 3  25 55 3  25 56 3  25 57 3  26 2 5  26 3 5  26 4 5  26 7 5  26 8 5  26 52 3  26 53 3  26 54 3  27 3 5  27 5 5  27 6 5  27 7 5  27 8 5  39 30 1  39 31 1  39 33 1  41 30 1  41 31 1  41 47 1 | 28 4 5  28 6 5  28 7 5  28 9 5  28 10 5  28 11 5  28 12 5  28 29 1  28 30 1  29 2 5  29 3 5  29 5 5  29 6 5  29 7 5  29 8 5  29 29 1  29 30 1  29 32 1  29 33 1  29 36 1  30 2 5  30 3 5  30 4 5  30 5 5  30 7 5  30 10 5  30 11 5  30 26 1  30 27 1  38 35 1  38 48 1  38 51 1  38 52 1  31 6 5  31 9 5  31 10 5  31 26 1  31 27 1  31 29 1  31 30 1  31 33 1  31 34 1  32 2 5  32 3 5  32 6 5  32 7 5  32 25 1 |

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