Contemporary Intelligent Information Techniques (CIIT)
Practice #5 (28/10/2016)
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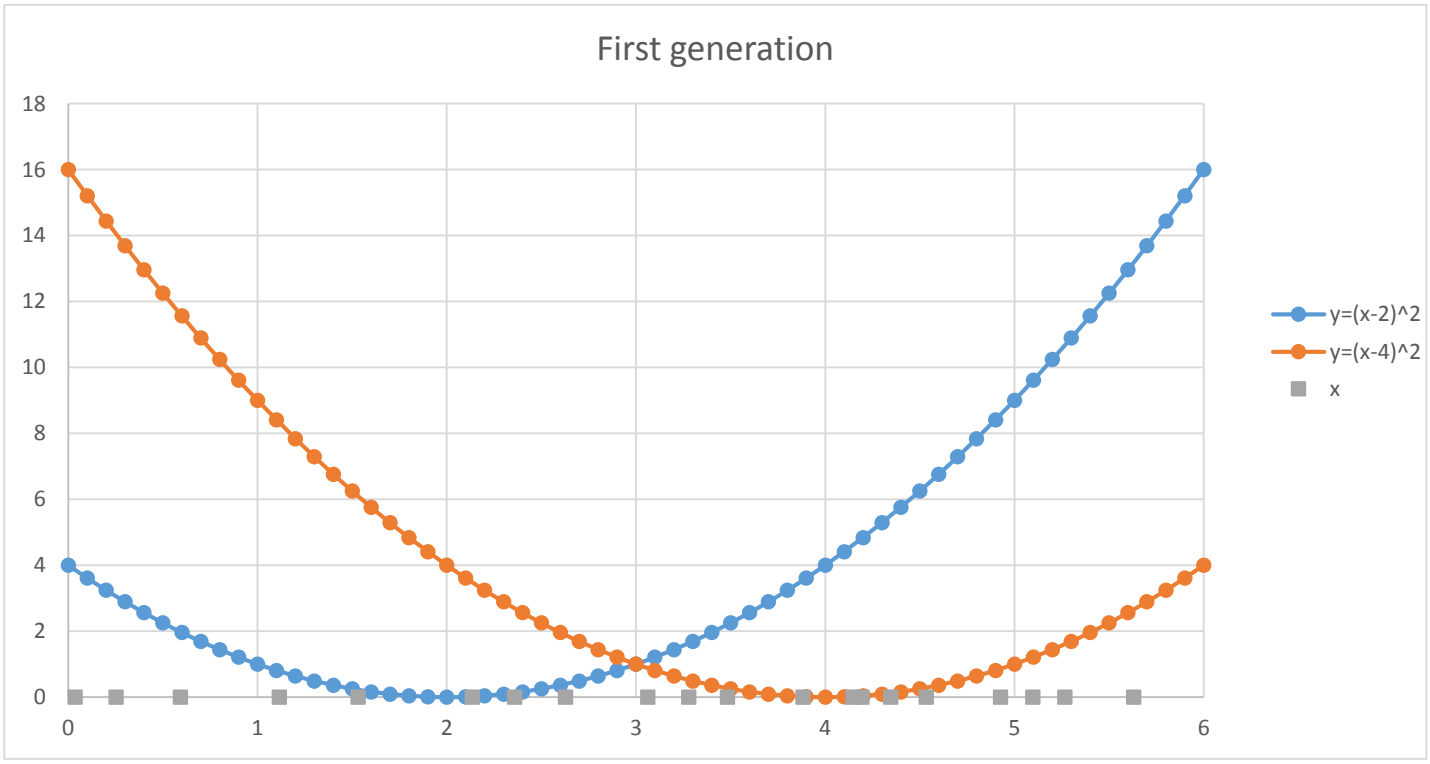
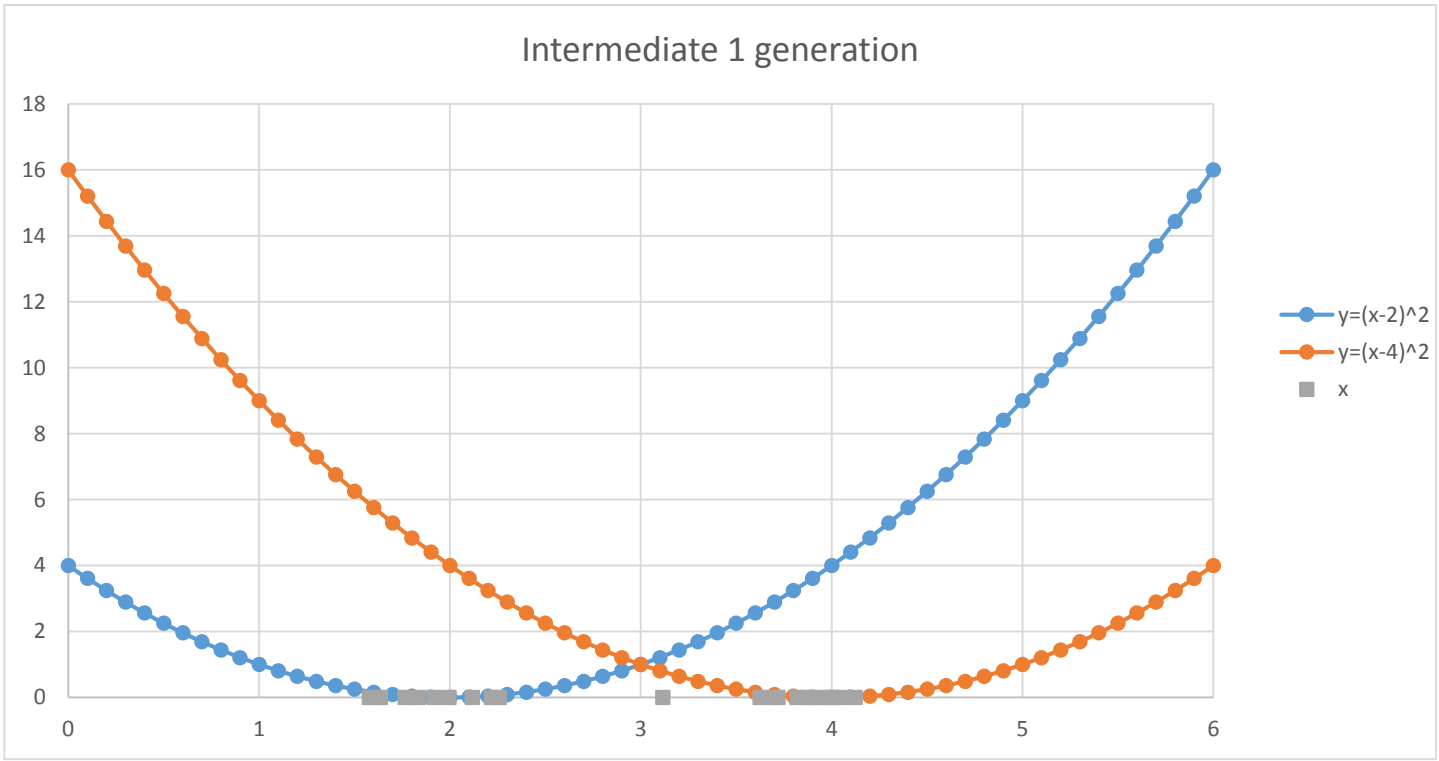
LabWork #5 Parate Optimum Solution- Dominate & Rank

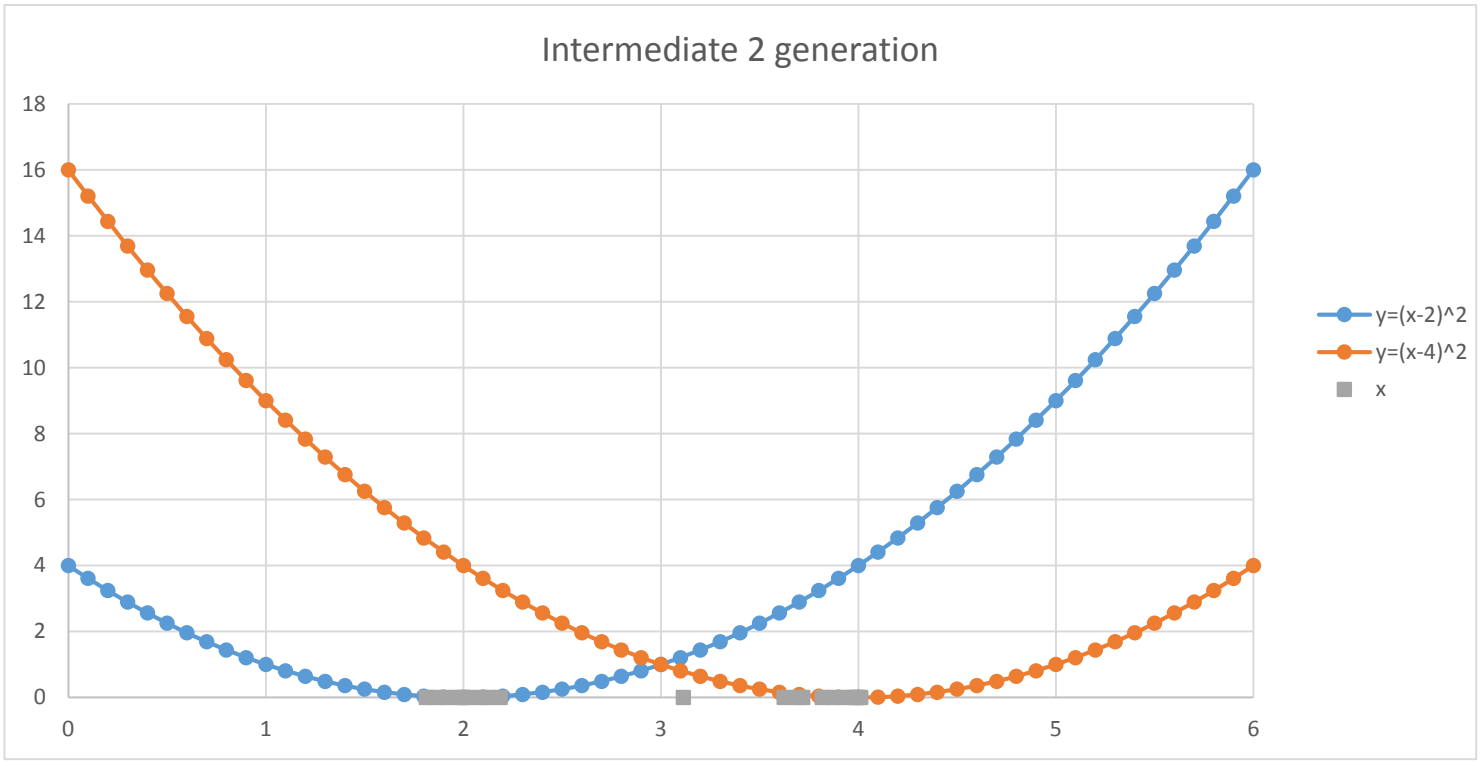
First				
0000101011	x=0.2521	y1=3.0548	y2=14.0460	rank=1
0001100101	x=0.5923	y1=1.9814	y2=11.6119	rank=2
1110000010	x=5.2668	y1=10.6723	y2=1.6049	rank=1
0010111110	x=1.1143	y1=0.7843	y2=8.3268	rank=3
0000000110	x=0.0351	y1=3.8604	y2=15.7197	rank=0
1101100101	x=5.0967	y1=9.5900	y2=1.2029	rank=2
1000001010	x=3.0615	y1=1.1269	y2=0.8806	rank=6
1101001000	x=4.9266	y1=8.5654	y2=0.8587	rank=3
1010010110	x=3.8826	y1=3.5445	y2=0.0137	rank=9
1111000000	x=5.6304	y1=13.1805	y2=2.6585	rank=0
1100000101	x=4.5337	y1=6.4197	y2=0.2848	rank=4
1011000011	x=4.1466	y1=4.6080	y2=0.0214	rank=7
1000101111	x=3.2785	y1=1.6347	y2=0.5204	rank=7
1011100101	x=4.3460	y1=5.5039	y2=0.1197	rank=5
0110010010	x=2.3577	y1=0.1280	y2=2.6969	rank=5
1011001011	x=4.1935	y1=4.8116	y2=0.0374	rank=6
0101101100	x=2.1348	y1=0.0181	y2=3.4786	rank=5
1001010010	x=3.4838	y1=2.2018	y2=0.2663	rank=7
0100000101	x=1.5307	y1=0.2201	y2=6.0969	rank=4
0111000000	x=2.6275	y1=0.3938	y2=1.8835	rank=5



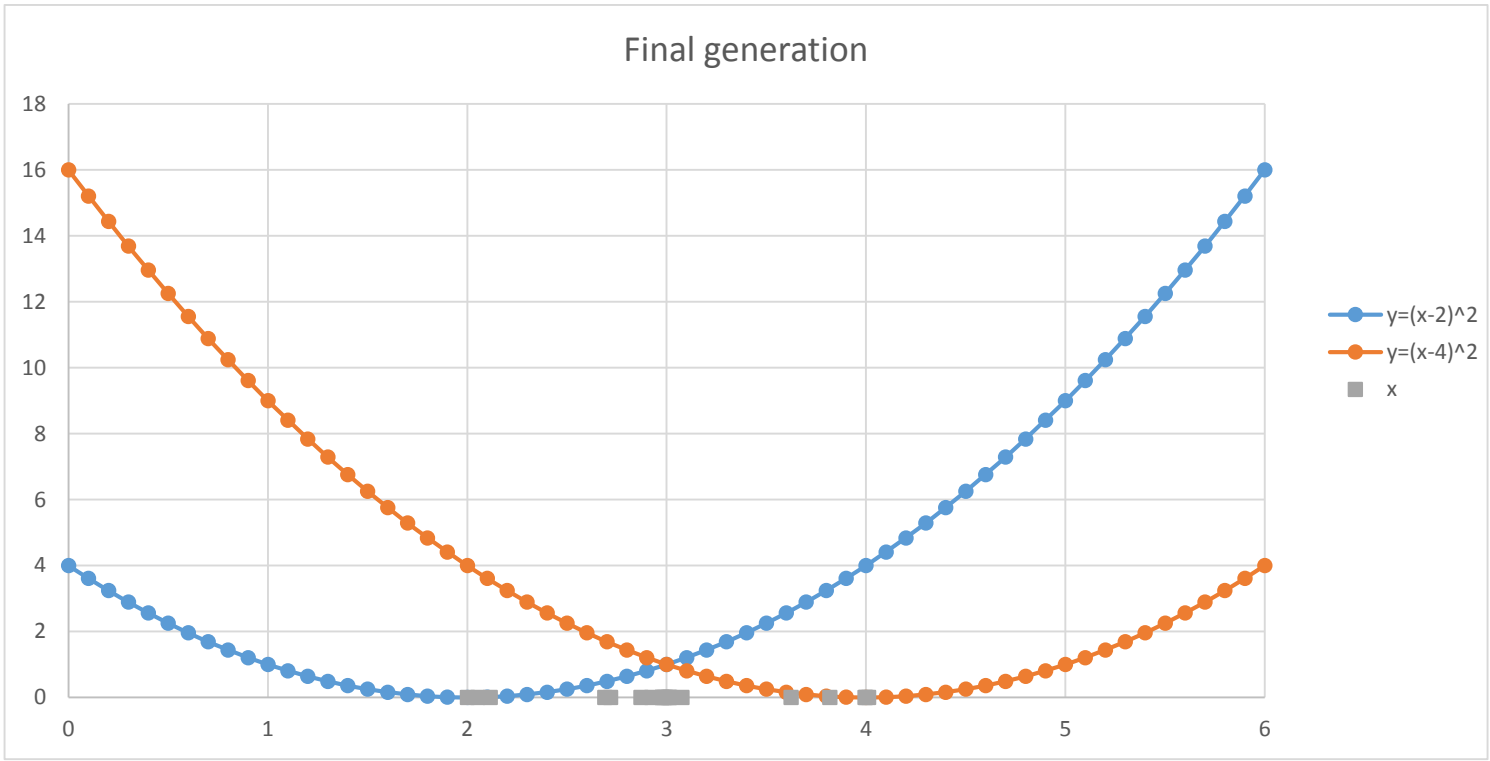
Intermediate 1				
0100010111	x=1.6363	y1=0.1322	y2=5.5867	rank=1
0100101101	x=1.7653	y1=0.0550	y2=4.9934	rank=2
1010110100	x=4.0586	y1=4.2380	y2=0.0034	rank=1
0100111001	x=1.8357	y1=0.0269	y2=4.6838	rank=3
0100001101	x=1.5777	y1=0.1783	y2=5.8674	rank=0
1010101010	x=4.0	y1=4.0	y2=0.0	rank=2
0110000001	x=2.2580	y1=0.0665	y2=3.0343	rank=2
1010100111	x=3.9824	y1=3.9299	y2=3.0959	rank=2
1001110101	x=3.6891	y1=2.8532	y2=0.0966	rank=0
1010111111	x=4.1231	y1=4.5078	y2=0.0151	rank=0
1010011011	x=3.9120	y1=3.6558	y2=0.0077	rank=1
1001111010	x=3.7184	y1=2.9531	y2=0.0792	rank=0
1000010011	x=3.1143	y1=1.2418	y2=0.7843	rank=0
1010010100	x=3.8709	y1=3.5005	y2=0.0166	rank=0
0101101001	x=2.1173	y1=0.0137	y2=3.5445	rank=4
1010001011	x=3.8181	y1=3.3057	y2=0.0330	rank=0
0101010100	x=1.9941	y1=3.4399	y2=4.0234	rank=5
1001101010	x=3.6246	y1=2.6394	y2=0.1409	rank=0
0101000111	x=1.9178	y1=0.0067	y2=4.3351	rank=4
0101111010	x=2.2170	y1=0.0470	y2=3.1790	rank=3

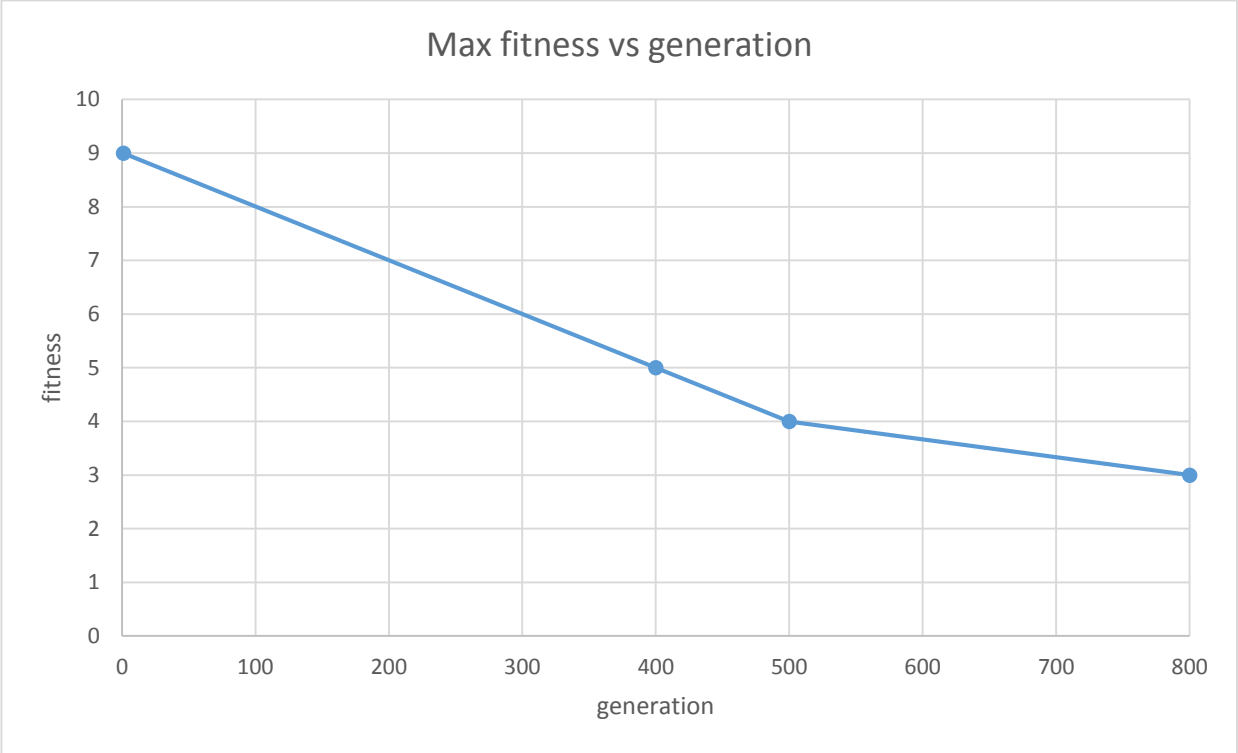


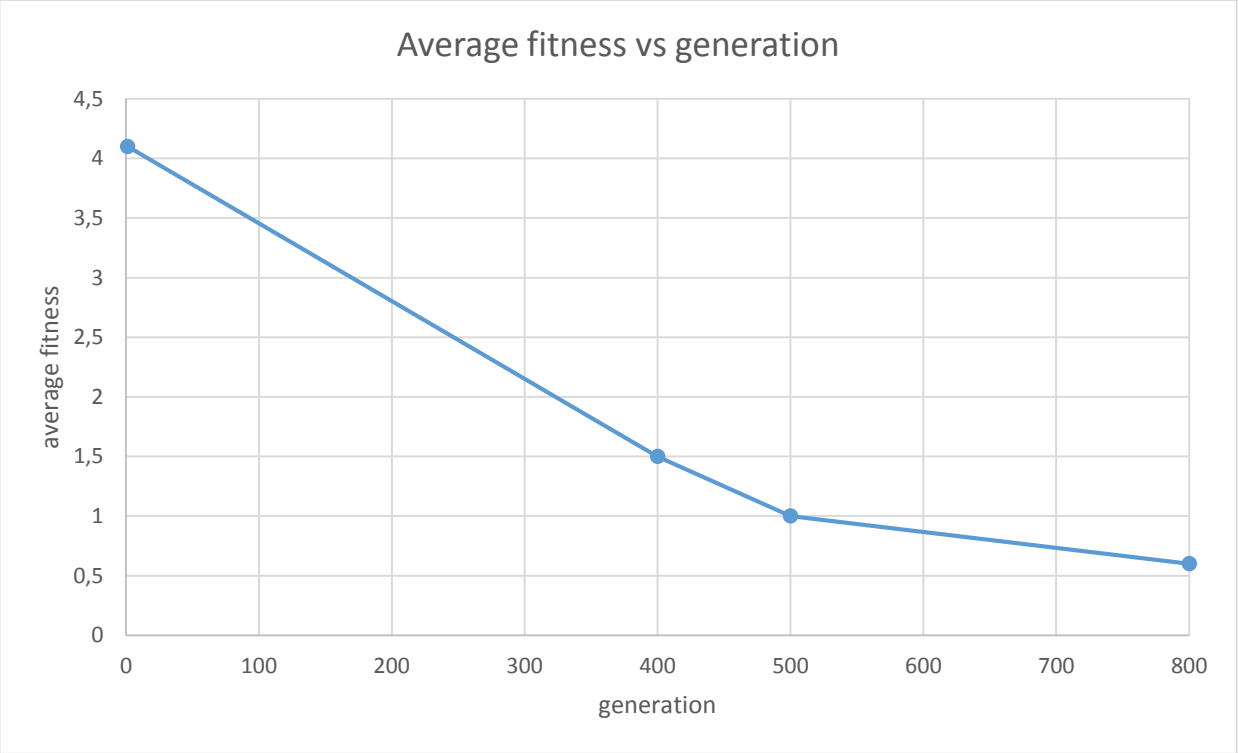
Intermediate 2				
0100111101	x=1.8592	y1=0.0198	y2=4.5828	rank=1
0101000111	x=1.9178	y1=0.0067	y2=4.3351	rank=2
1010101010	x=4.0	y1=4.0	y2=0.0	rank=1
0101010011	x=1.9882	y1=1.3759	y2=4.0470	rank=3
0100110101	x=1.8123	y1=0.0352	y2=4.7859	rank=0
1010101001	x=3.9941	y1=3.9765	y2=3.4399	rank=1
0101110101	x=2.1876	y1=0.0352	y2=3.2844	rank=1
1010100110	x=3.9765	y1=3.9067	y2=5.5039	rank=0
1001110101	x=3.6891	y1=2.8532	y2=0.0966	rank=0
1010101100	x=4.0117	y1=4.0470	y2=1.3759	rank=0
1010011101	x=3.9237	y1=3.7008	y2=0.0058	rank=0
1001111010	x=3.7184	y1=2.9531	y2=0.0792	rank=0
1000010011	x=3.1143	y1=1.2418	y2=0.7843	rank=0
1010010100	x=3.8709	y1=3.5005	y2=0.0166	rank=0
0101100100	x=2.0879	y1=0.0077	y2=3.6558	rank=2
1010001011	x=3.8181	y1=3.3057	y2=0.0330	rank=0
0101011001	x=2.0234	y1=5.5039	y2=3.9067	rank=3
1001101010	x=3.6246	y1=2.6394	y2=0.1409	rank=0
0101010101	x=2.0	y1=0.0	y2=4.0	rank=4
0101101010	x=2.1231	y1=0.0151	y2=3.5225	rank=2



Last				
0101010011	x=2.9882	y1=1.3759	y2=4.0470	rank=1
0101010100	x=2.9941	y1=3.4399	y2=4.0234	rank=2
1010101010	x=4.0	y1=4.0	y2=0.0	rank=1
0101010101	x=2.0	y1=0.0	y2=4.0	rank=3
0101010001	x=2.9765	y1=5.5039	y2=4.094	rank=0
1010101001	x=3.9941	y1=3.9765	y2=3.4399	rank=1
0101100010	x=3.0762	y1=0.0058	y2=3.7008	rank=0
1010100110	x=2.9765	y1=3.9067	y2=5.5039	rank=0
1001110101	x=2.6891	y1=2.8532	y2=0.0966	rank=0
1010101100	x=4.0117	y1=4.0470	y2=1.3759	rank=0
1010011101	x=2.9237	y1=3.7008	y2=0.0058	rank=0
1001111010	x=2.7184	y1=2.9531	y2=0.0792	rank=0
1000010011	x=2.1143	y1=1.2418	y2=0.7843	rank=0
1010010100	x=2.8709	y1=3.5005	y2=0.0166	rank=0
0101011000	x=3.0175	y1=3.0959	y2=3.9299	rank=1
1010001011	x=3.8181	y1=3.3057	y2=0.0330	rank=0
0101010111	x=3.0117	y1=1.3759	y2=3.9532	rank=1
1001101010	x=3.6246	y1=2.6394	y2=0.1409	rank=0
0101010110	x=3.0058	y1=3.4399	y2=3.9765	rank=2
0101011110	x=2.0527	y1=0.0027	y2=3.7916	rank=0







Source code (written in Java)

File Individual.java:

```
import java.util.Arrays;
import java.util.concurrent.ThreadLocalRandom;

public class Individual {

    public static final int GENE_LENGTH = 10;

    private int[] genes;
    private double x;
    private double y1;
    private double y2;
    private int rank;
```

```
    public Individual(boolean initialize) {
        genes = new int[GENE_LENGTH];

        if (initialize) {
            generateIndividual();
            this.x = calculateX();
            this.y1 = calculateY1();
            this.y2 = calculateY2();
            this.rank = 0;
        }
    }

    public Individual(int[] genes) {
        this.genes = genes;
        this.x = calculateX();
        this.y1 = calculateY1();
        this.y2 = calculateY2();
        this.rank = 0;
    }

    public double getX() {
        return x;
    }

    public double getY1() {
        return y1;
    }

    public double getY2() {
        return y2;
    }

    public int getRank() {
        return rank;
    }

    public int updateRank() {
        return ++this.rank;
    }

    public void resetRank() {
        this.rank = 0;
    }

    public void generateIndividual() {
        for (int i = 0; i < GENE_LENGTH; ++i) {
            genes[i] = ThreadLocalRandom.current().nextInt(0, 2);
        }
    }

    public double calculateX() {
        return Integer.parseInt(Arrays.toString(genes).replaceAll("[,\\[\\]
]", ""), 2) / 170.5;
    }

    public double calculateY1() {
        return Math.pow(x - 2, 2);
    }

    public double calculateY2() {
        return Math.pow(x - 4, 2);
    }

    public int[] getGenesBeforeCutPoint(int cutPoint) {
        int[] genes = new int[cutPoint];
        System.arraycopy(this.genes, 0, genes, 0, cutPoint);
        return genes;
    }
```

```
    public int[] getGenesAfterCutPoint(int cutPoint) {
        int[] genes = new int[GENE_LENGTH - cutPoint];
        System.arraycopy(this.genes, cutPoint, genes, 0, genes.length);
        return genes;
    }

    @Override
    public boolean equals(Object o) {
        if (this == o) return true;
        if (o == null || getClass() != o.getClass()) return false;

        Individual that = (Individual) o;

        if (Double.compare(that.y1, y1) != 0) return false;
        if (Double.compare(that.y2, y2) != 0) return false;
        if (Double.compare(that.x, x) != 0) return false;
        if (rank != that.rank) return false;
        return Arrays.equals(genes, that.genes);

    }

    @Override
    public int hashCode() {
        int result;
        long temp;
        result = Arrays.hashCode(genes);
        temp = Double.doubleToLongBits(y1);
        result = 31 * result + (int) (temp ^ (temp >>> 32));
        temp = Double.doubleToLongBits(y2);
        result = 31 * result + (int) (temp ^ (temp >>> 32));
        temp = Double.doubleToLongBits(x);
        result = 31 * result + (int) (temp ^ (temp >>> 32));
        result = 31 * result + rank;
        return result;
    }

    @Override
    public String toString() {
        return "Individual{" +
                "genes=" + Arrays.toString(genes) +
                ", x=" + x +
                ", y1=" + y1 +
                ", y2=" + y2 +
                ", rank=" + rank +
                '}';
    }
}
```

File Population.java:

```
import java.util.Arrays;

public class Population {

    public static final int POPULATION_SIZE = 20;

    private Individual[] individuals;

    public Population(boolean initialize) {
        individuals = new Individual[POPULATION_SIZE];

        if (initialize) {
            for (int i = 0; i < POPULATION_SIZE; ++i) {
                individuals[i] = new Individual(true);
            }
        }
    }
```

```
    public Population(Individual[] individuals) {
        this.individuals = new Individual[POPULATION_SIZE];
        System.arraycopy(individuals, 0, this.individuals, 0,
individuals.length);
    }

    public Individual getIndividual(int index) {
        return individuals[index];
    }

    public void replaceIndividual(Individual individual, Individual child) {
        for (int i = 0; i < individuals.length; ++i) {
            if (individuals[i].equals(individual)) {
                individuals[i] = child;
                break;
            }
        }
    }

    public Individual[] getAllIndividuals() {
        return individuals;
    }

    public void calculateRankForAllIndividuals() {
        resetRank();
        for (int i = 0; i < POPULATION_SIZE; ++i) {
            for (int j = 0; j < POPULATION_SIZE; ++j) {
                if (i != j && (individuals[i].getY1() <
individuals[j].getY1() &&
                                    individuals[i].getY2() <
individuals[j].getY2())) {
                        individuals[i].updateRank();
                }
            }
        }

    }

    private void resetRank() {
        for (Individual individual: individuals) {
            individual.resetRank();
        }
    }

    @Override
    public String toString() {
        return "Population{\n" + Arrays.toString(individuals) + "}\n";
    }
}
```

File GeneticAlgorithm.java:

```
import java.util.concurrent.ThreadLocalRandom;

public class GeneticAlgorithm {

    private Population population;

    public GeneticAlgorithm(Population population) {
        this.population = population;
    }

    public Population run() {
        Population nextGeneration = new
Population(population.getAllIndividuals());
        nextGeneration.calculateRankForAllIndividuals();
```

```
        for (int i = 0; i < Population.POPULATION_SIZE; ++i) {
            Individual[] parents = chooseParents(nextGeneration);
            int cutPoint = ThreadLocalRandom.current().nextInt(0,
Individual.GENE_LENGTH);
            Individual[] children = crossover(parents, cutPoint);
            Individual child = getBetterIndividualFromTwoChildren(children);
            calculateIndividualRank(child);
            Individual individual =
findIndividualThatMostSimilarToChild(child);

            if (childBetterThanParent(individual, child)) {
                nextGeneration.replaceIndividual(individual, child);
                nextGeneration.calculateRankForAllIndividuals();
            }
        }

        population = nextGeneration;
        return population;
    }

    private Individual[] chooseParents(Population fittestIndividuals) {
        return new Individual[]
{fittestIndividuals.getIndividual(ThreadLocalRandom.current().nextInt(0,
Population.POPULATION_SIZE)),

fittestIndividuals.getIndividual(ThreadLocalRandom.current().nextInt(0,
Population.POPULATION_SIZE))};
    }

    private Individual[] crossover(Individual[] parents, int curPoint) {
        Individual[] descendants = new Individual[2];

        int[] firstDescendantGenes =
concat(parents[0].getGenesBeforeCutPoint(curPoint),
                parents[1].getGenesAfterCutPoint(curPoint));
        int[] secondIndividualGenes =
concat(parents[0].getGenesAfterCutPoint(curPoint),
                parents[1].getGenesBeforeCutPoint(curPoint));

        descendants[0] = new Individual(firstDescendantGenes);
        descendants[1] = new Individual(secondIndividualGenes);

        return descendants;
    }

    private Individual getBetterIndividualFromTwoChildren(Individual[]
children) {
        return calculateIndividualRank(children[0]) >
calculateIndividualRank(children[1]) ? children[0] : children[1];
    }

    private Individual findIndividualThatMostSimilarToChild(Individual child)
{
        Individual individual = population.getIndividual(0);
        double minX = Math.abs(population.getIndividual(0).getX() -
child.getX());
        for (int i = 1; i < Population.POPULATION_SIZE; ++i) {
            double tempMinX = Math.abs(population.getIndividual(i).getX() -
child.getX());
            if (tempMinX < minX) {
                minX = tempMinX;
                individual = population.getIndividual(i);
            }
        }
        return individual;
    }

    private boolean childBetterThanParent(Individual individual, Individual
```

```
child) {
        return child.getRank() > individual.getRank() || (child.getY1() <
individual.getY1() && child.getY2() < individual.getY2());
    }

    private int calculateIndividualRank(Individual individual) {
        for (int i = 0; i < Population.POPULATION_SIZE; ++i) {
            if (individual.getY1() < population.getIndividual(i).getY1() &&
                individual.getY2() < population.getIndividual(i).getY2()) {
                individual.updateRank();
            }
        }
        return individual.getRank();
    }

    private int[] concat(int[] genes1, int[] genes2) {
        int[] genes = new int[Individual.GENE_LENGTH];

        System.arraycopy(genes1, 0, genes, 0, genes1.length);
        System.arraycopy(genes2, 0, genes, genes1.length, genes2.length);

        return genes;
    }

}
```

File Main.java:

```
import java.io.FileWriter;
import java.io.IOException;

/**
 * 10 ген 20 хромосом; x=0:6  (x-2)^2 (x-4)^2
 */
public class Main {
    public static void main(String[] args) throws IOException {
        FileWriter writer = new FileWriter("output.txt");
        Population population = new Population(true);
        GeneticAlgorithm geneticAlgorithm = new GeneticAlgorithm(population);

        for (int i = 0; i < 1000; ++i) {
            population = geneticAlgorithm.run();
            System.out.println("ITERATION #" + (i + 1));
            writer.write("ITERATION #" + (i + 1) + ":\n");
            for (Individual individual: population.getAllIndividuals()) {
                writer.write(individual.toString() + "\n");
                System.out.println(individual);
            }
        }
    }
}
```