COMP 5660/6660 Fall 2023 Exam 1 Key

This is a closed-book, closed-notes exam. The sum of the max points for all the questions is 74, but note that the max exam score will be capped at 70 (i.e., there are 4 bonus points, but you can't score more than 100%). You have exactly 50 minutes to complete this exam. Keep your answers clear and concise while complete. Good luck!

The first seven questions are about the following EA experimental log data.

Eval	Local adult average fitness	Local adult best fitness
Run 1		
50	2.5	3.8
60	2.6	3.8
70	2.7	3.7
80	2.6	3.9
90	2.8	4.1
100	3.1	4.3
Run 2		
50	2.1	3.4
⋮		
90	3.0	4.2
100	2.9	4.3
Run 3		
50	1.6	2.7
⋮		
90	3.0	4.5
100	2.9	4.3
⋮	⋮	⋮
Run 30		
50	2.1	3.4
⋮		
90	2.7	3.9
100	2.9	4.3

Run	Global adult best fitness
1	4.3
2	4.4
3	4.5
⋮	⋮
30	4.3

1. What is μ? [1 pt]

   50

2. What is λ? [1 pt]

   10

3. Given that the EA is using the limit of 100 fitness evaluations as its termination criterion, write out the formula for computing the number of generations (i.e., generational cycles) completed by the EA each run, in terms of μ, λ, and *evaluation_limit*, and your computation of that number of generations. Note that the randomly initialized population is not counted as a generation. [3 pts]

   $num\_of\_generations = (evaluation\_limit - \mu)/\lambda = (100 - 50)/10 = 5$

4. Write out the formula for computing the total number of fitness evaluations for this entire experiment in terms of μ, λ, *num_of_generations*, and *num_of_runs*, and your computation of that number. [3 pts]

   $evals\_per\_experiment = num\_of\_runs \cdot (\mu + \lambda \cdot num\_of\_generations) = 30 \cdot (50 + 10 \cdot 5) = 3000$

5. The log data indicate: [4 pts]

   (a) An error in either the EA or the logging, because it shouldn't be possible for the fittest individual to be replaced by a less fit individual as indicated for both Run 1 & 3.

   (b) An error in either the EA or the logging, because it shouldn't be possible for the local adult best fitness to increase while the local adult average fitness decreases as indicated in Run 1 from 70 to 80 evals.

   (c) An error in either the EA or the logging, because it shouldn't be possible for the local adult best fitness to decrease while the local adult average fitness increases as indicated in Run 1 from 60 to 70 evals.

   Select one of:

   - a [2]
   - b [0]
   - c [0]
   - a and b [1]
   - a and c [1]
   - b and c [0]
   - a, b, and c [1]
   - **none of a, b, nor c**; the log data indicate the EA employs a non-elitist survival selection

6. The log data indicate the problem being solved is: [4 pts]

   (a) unimodal, because all the runs converged on the same local adult best fitness of 4.3

   (b) multimodal, because not all the runs converged on the same local adult average fitness

   (c) multimodal, because not all the runs converged on the same global adult best fitness

   Select one of:

   - a [1]
   - b [0]
   - c [2]
   - b and c [1]
   - **none of a, b, nor c**; the EA hasn't converged yet and also EAs aren't suited for determining modality

7. The log data indicate: [4 pts]

   (a) μ, λ, and the number of generations appear to have been chosen well as they're sufficient for the EA to converge in all runs on the same local adult best fitness

   (b) the EA hasn't converged yet by the end of the runs, so μ should be decreased in order to free up evals to increase λ

   (c) the EA hasn't converged yet by the end of the runs, so the number of evaluations per run should be increased, with if needed a decrease in the number of runs to manage total computational time while maintaining sufficient runs for statistical purposes

   Select one of:

   - a [1]
   - b [2]
   - **c**
   - b and c [3]
   - none of a, b, nor c [0]

The next three questions are about the cutting stock problem from your Assignment 1 series, with phenotype defined as a two-dimensional grid of cells which are either covered or not covered.

8. The cutting stock problem problem from your Assignment 1 series is: [4 pts]

   (a) An optimization problem because the model is known and you're searching for the optimal inputs to the model

   (b) A modeling problem because you're modeling (designing) a stock cutting layout

   (c) A simulation problem because it simulates the real-world physics of unused stock being wasted

   Select one of:

   - **a**
   - b [0]
   - c [0]
   - a and b [2]
   - a and c [2]
   - b and c [0]
   - a, b, and c [1]
   - none of a, b, nor c [0]

9. The genetic encoding for the cutting stock problem from your Assignment 1 series is: [4 pts]

   (a) pleitropic
   (b) polygenic
   (c) phenotypic

   Select one of:

   - a [2]
   - b [2]
   - c [0]
   - **a and b**; because a shape has the potential to cover multiple grid cells (pleitropy) and a grid cell has the potential to be covered by different shapes (polygeny), although not simultaneously
   - a and c [1]
   - b and c [1]
   - a, b, and c [2]
   - none of a, b, nor c [0]

10. The decoding function for the cutting stock problem from your Assignment 1 series is: [4 pts]

    (a) surjective
    (b) injective
    (c) bijective

    Select one of:

    - a [2]; it's not surjective, because the set of shapes is insufficient to cover all grid cell configurations
    - b [2]; it's not injective, because the same shapes with different starting coordinates, but appropriately chosen rotations, map to the same phenotype
    - c [0]
    - a and b [0]
    - a and c [0]
    - b and c [0]
    - a, b, and c [0]
    - **none of a, b, nor c**

11. What is the binary gray code for the standard binary number 010010001? [4 pts]

    011011001

12. What is the standard binary number encoded by the binary gray code 010010001? [4 pts]

    011100001

13. Given the following two parents with permutation representation:
    $p1 = (864297531)$
    $p2 = (975318642)$
    compute the first offspring with Order Crossover, using crossover points between the 4th and 5th loci and between the 7th and 8th loci. Show your offspring construction steps. [4 pts]

    (a) $\cdot\cdot\cdot\cdot 975 \cdot\cdot$
    (b) **3 1 8 6 9 7 5 4 2**

14. Given the following two parents with permutation representation:
$p1 = (864297531)$
$p2 = (975318642)$
compute the first offspring with Cycle Crossover. Show first the cycles you've identified and then the construction of the offspring. [6 pts]

Cycle 1: 8-9-1-2-3-4-5-6-7
Construction of first offspring by scanning parents from left to right, starting at parent 1 and alternating parents:

(a) Add cycle 1 from parent 1: **8 6 4 2 9 7 5 3 1**

15. Given the following two parents with permutation representation:
$p1 = (123456789)$
$p2 = (891234567)$
compute the first offspring with PMX, using crossover points between the 2nd and 3rd loci and between the 7th and 8th loci. Show your offspring construction steps. [10 pts]

(a) $\cdot\cdot$ 34567 $\cdot\cdot$
(b) $\cdot\cdot$ 34567 $\cdot$ 1
(c) $\cdot\cdot$ 3456721
(d) **8 9 3 4 5 6 7 2 1**

16. Given the following parents with permutation representation:
$p1 = (123456789)$
$p2 = (987123654)$
compute the first offspring with Edge Crossover, except that for each random choice you instead select the lowest element. Show how you arrived at your answer by filling the following templates: [14 pts]

Edge Table:

Element	Edges

Construction Table:

Element Selected	Reason Selected	Partial Result

Original Edge Table:

Element	Edges	Element	Edges
1	9,2+,7	6	5+,7,3
2	1+,3+	7	6,8+,1
3	2+,4,6	8	7+,9+
4	3,5+,9	9	8+,1,4
5	4+,6+		

Construction Table:

Element selected	Reason	Partial result
1	Lowest	1
2	Common edge	1,2
3	Only element	1,2,3
4	Equal list size, so lowest	1,2,3,4
5	Common edge	1,2,3,4,5
6	Only element	1,2,3,4,5,6
7	Only element	1,2,3,4,5,6,7
8	Only element	1,2,3,4,5,6,7,8
9	Last element	**1,2,3,4,5,6,7,8,9**

Edge Table After Step 1:

Element	Edges	Element	Edges
1	9,2+,7	6	5+,7,3
2	3+	7	6,8+
3	2+,4,6	8	7+,9+
4	3,5+,9	9	8+,4
5	4+,6+		

Edge Table After Step 2:

Element	Edges	Element	Edges
		6	5+,7,3
2	3+	7	6,8+
3	4,6	8	7+,9+
4	3,5+,9	9	8+,4
5	4+,6+		

Edge Table After Step 3:

Element	Edges	Element	Edges
		6	5+,7
		7	6,8+
3	4,6	8	7+,9+
4	5+,9	9	8+,4
5	4+,6+		

Edge Table After Step 4:

Element	Edges	Element	Edges
		6	5+,7
		7	6,8+
		8	7+,9+
4	5+,9	9	8+
5	6+		

Edge Table After Step 5:

Element	Edges	Element	Edges
		6	7
		7	6,8+
		8	7+,9+
		9	8+
5	6+		

Edge Table After Step 6:

Element	Edges	Element	Edges
		6	7
		7	8+
		8	7+,9+
		9	8+

Edge Table After Step 7:

Element	Edges	Element	Edges
		7	8+
		8	9+
		9	8+

Edge Table After Step 8:

Element	Edges	Element	Edges
		8	9+
		9	