COMP 5660/6660 Fall 2025 Exam 1

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. Good luck!

Multiple Choice Questions

1. Which of the following should be determined to decide whether the use of an EA is justified? [4 pts]

   (a) Is there an exact mathematical solution?

   (b) How large is the search space?

   (c) How much wall-time does evaluating the objective function take?

   (d) Does running a hill-climbing algorithm from different starting points converge on different optima?

   Select one of:

   - a
   - b
   - c
   - d
   - a and b
   - a and c
   - a and d
   - b and c
   - b and d
   - c and d
   - a, b, and c
   - a, b, and d
   - a, c, and d
   - b, c, and d
   - a, b, c, and d
   - none of a, b, c, nor d

Alice is configuring an EA with permutation representation to repeatedly solve instances of a route planning problem with a large number of way points with no repeats. Answer the following two questions about her EA:

2. Which of the following recombination operators should she consider using? [4 pts]

   (a) Partially Mapped Crossover (PMX)
   (b) Order Crossover
   (c) Cycle Crossover
   (d) Edge Crossover

   Select one of:

   - a
   - b
   - c
   - d
   - a and b
   - a and c
   - a and d
   - b and c
   - b and d
   - c and d
   - a, b, and c
   - a, b, and d
   - a, c, and d
   - b, c, and d
   - a, b, c, and d
   - none of a, b, c, nor d

3. If she runs 5 experiments to test different EA configurations, with each configuration consisting of 50 runs to obtain statistically sound results, each run consists of 100 generations, she holds μ steady at 1,000 and λ at 10, and each evaluation takes 1 second in wall time, then how much wall time does she need to run all five experiments? [4 pts]

   (a) 250,000 seconds
   (b) 251,000 seconds
   (c) 255,000 seconds
   (d) 500,000 seconds
   (e) 25,250,000 seconds

   Select one of:

   - a
   - b
   - c
   - d
   - e

4. Bob runs a steady state EA where each generation λ old individuals are replaced by λ new individuals, with $\mu = 100$, for 200 generations, with a generational gap of 0.01. What is the value of λ? [4 pts]

   (a) 1
   (b) 2
   (c) 200
   (d) 10,000
   (e) 20,000

   Select one of:

   - a
   - b
   - c
   - d
   - e
   - There is insufficient information provided to determine the value of λ.
   - None of the above

5. Carla is configuring an EA with a binary representation where the loci correspond to, and are ordered the same as, elements in a circular arrangement, such that adjacent genes are related to one another, including the first gene to the last gene. Would an n-point crossover operator be appropriate? [4 pts]

   (a) Yes, n-point crossover is defined for binary representations.
   (b) Yes, but only if n is an odd number to avoid positional bias.
   (c) Yes, but only if n is an even number to avoid distributional bias.
   (d) No, n-point crossover is not defined for binary representations.
   (e) No, that would cause positional bias.
   (f) No, that would cause distributional bias.

   Select one of:

   - a
   - b
   - c
   - d
   - e
   - f
   - None of the above

6. Alice and Bob run their EAs on a target benchmark. Bob employs a two-tailed Welch's t-test with $\alpha = 0.05$ and sample size $n = 30$ in order to statistically analyze the difference between their EAs. Bob's EA has a higher average performance than Alice's EA. The test returns a p of 0.13. Bob repeats the experiment, this time with $n = 100$, obtaining a p of 0.09. What should Bob do now? [4 pts]

   (a) He should iteratively increase n and rerun the experiment to see if he can decrease p to below α, at which point he can claim that his EA beats Alice's.

   (b) He should increase α to be higher than p in order to have the statistical result supporting the claim that his EA beats Alice's.

   (c) He should settle for his EA not beating Alice's, because making n or α arbitrarily high in order to demonstrate a statistical difference is not scientifically meaningful.

   (d) This analysis is flawed because Bob knows that his EA has a higher average than Alice's, so he should be using a one-tailed t-test rather than a two-tailed, which would increase the sensitivity of the test.

   Select one of:

   - a
   - b
   - c
   - d
   - None of the above

7. Would you expect in general a change in the performance of an EA if you change λ but maintain the same total number of fitness evaluations by making a compensatory change in the number of generations? [4 pts]

   (a) no, because the EA's performance depends on its representation (genotype) and its fitness function (environment/problem) which together determine its phenotype (expression of the genotype in a given environment)

   (b) yes, because increasing λ will decrease the generational gap and therefore lead to a better exploitation of the genetic knowledge encoded in the current population

   (c) yes, because this will change the ratio of exploitation versus exploration

   (d) no, because as long as the total number of fitness evaluations remains constant, the total number of recombinations as well as the total number of mutations remains per definition constant too and therefore the EA's performance remains unchanged

   Select one of:

   - a
   - b
   - c
   - d
   - none of a, b, c, nor d

8. Which of the following is not a pro for using an EA: [4 pts]
   (a) Ability to obtain satisfactory solutions for many hard problems
   (b) Solution availability while solving
   (c) Robustness when dealing with noisy problems
   (d) Inherent parallelism
   (e) Ability to feasibly optimize non-differentiable problem classes

   Select one of:

   - a
   - b
   - c
   - d
   - e
   - none of a, b, c, d, nor e

9. Stochastic Universal Sampling can augment Fitness Proportional Selection by: [4 pts]
   (a) reducing sampling error
   (b) accounting for negative fitness
   (c) facilitating even selective pressure
   (d) reducing the likelihood of premature convergence

   Select one of:

   - a
   - b
   - c
   - d
   - a and b
   - a and c
   - a and d
   - b and c
   - b and d
   - c and d
   - a, b, and c
   - a, b, and d
   - a, c, and d
   - b, c, and d
   - all of a, b, c, and d
   - none of a, b, c, nor d

10. What is the binary gray code for the standard binary number 01010101? [4 pts]

11. What is the standard binary number encoded by the binary gray code 1011001110? [4 pts]

12. Given the following two parents with permutation representation:
$p1 = (728619543)$
$p2 = (286195437)$
compute the first offspring with Order Crossover, using crossover points between the 2nd and 3rd loci and between the 6th and 7th loci. Show your offspring construction steps. [4 pts]

13. Given the following two parents with permutation representation:
$p1 = (728619543)$
$p2 = (286195437)$
compute the first offspring with Cycle Crossover. Show first the cycles you've identified and then the construction of the offspring. [6 pts]

14. Given the following two parents with permutation representation:
$p1 = (728619543)$
$p2 = (286195437)$
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. [8 pts]

15. Given the following parents with permutation representation:
$p1 = (728619543)$
$p2 = (286195437)$
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: [12 pts]

Edge Table:

Element	Edges

Construction Table:

Element Selected	Reason Selected	Partial Result