Final Exam

Started: May 10 at 8:38am

Quiz Instructions

This exam must be completed as individual work -- you cannot discuss this exam, i.e., problems or solutions or related AMPL/Python code with anyone other than the course instructor or TA.

While the exam is not timed, you will only have one attempt. Note: you can log in and out of the Canvas Quiz as much as you like during the examination period, but you may submit only once! Also, note: LATE EXAM SUBMISSIONS WILL NOT BE ACCEPTED! Submit before the deadline!

There are two components to this exam.

First, you will complete the exam questions listed here in the *online quiz format*. Second, you will create and upload a PDF that details your work -- make sure to *upload all of your files* and/or figures to the Final Exam File Upload dropbox. This second component is primarily what will be graded. Clearly name your files. The PDF must show your solution and work -- it does not have to be fancy, just clear! You can and should copy and paste AMPL/Python code and/or screen shots in the PDF if it helps you answer the question.

You must complete BOTH components and submit BOTH prior to the deadline to receive credit for this exam!

Question 1 — 1 pts

On your PDF, please note that this exam question is for version #1.

The city of Centerville, OK is concerned about urban blight. Urban blight, also known as urban decay, is the deterioration of a previously functioning part of a town or city due to economic stagnation, ageing, neglect, and lack of financial support for maintenance. Blighted areas are characterized by abandoned homes and buildings, vacant lots with trash and weeds, vandalism, and the threat of crime and arson. Such areas also cause municipalities to lose considerable property tax revenue as a result of lower assessed property values throughout blighted neighborhoods.

To address the issue, Centerville has obtained a $15 million federal grant to revitalize its neighborhoods. The revitalization project (referred to as Project Renewal) has two phases: (i) demolish existing abandoned/condemned buildings, and (ii) build new buildings it their place.

Please read the following details closely to create a mathematical formulation that helps Centerville decide how to best use the Project Renewal fund.

4
- Up to 300 abandoned/condemned buildings may be demolished at a cost of $4000 each.

1
- Every building that is demolished frees up 0.25 acres of land for potential new development.
- The new development consists of (i) single homes, (ii) duplexes, and (iii) 1-acre open green spaces (a.k.a. “mini-parks”).
- The single homes each require 0.2 acres of land, each duplex requires 0.4 acres of land, and each mini-park requires 1 acre of land.

Obj
- The expected monetary value for Centerville through from the new property tax is $1500 for each single home, $2750 for each duplex, and $500 for each mini-park.

2
- The construction cost for a single home is $150,000, for a duplex is $190,000, and for a mini-park is $20,000.

3
- Single home units must constitute at least 20% of all new development units, duplex units must constitute at least 10% of all new development units, and the mini-parks (each is 1 “unit”) must constitute at least 5% of all new development units.

To maximize long-term value and reduce blight, how should Centerville best use its Renewal fund? That is, how many buildings should be demolished, how many single homes built, how many duplexes built, and how many mini-parks created to maximize expected property tax?

Part (1) Formulate a mathematical model (written, not coded) in which every set, variable, objective, and constraint are clearly described. (Include this on your PDF submission)

Part (2) Solve this problem as an integer program in AMPL and provide the solution and maximum objective value. (Include AMPL code in the the PDF submission, as well as all original AMPL files separately, also make sure to clearly show your solution for all decision variables in your PDF)

Part (3) What is the maximum expected property tax value? (Answer here on the Canvas quiz)

Knapsack variation - Maximize project taxes s.t. a tight construction budget.
- Costs = Clearing, contruction,

1. Available land constraint: = (newHomes*newHomeLand) <= (clearedHomes*clearedLand)
2. Cost constraint: (newHomes*costPerHome) + (clearedHomes*costPerCleared) <= totalBudget
3. Home types must be at least x%
4. ~~Only certain amount of cleared homes possible~~

Question 2 — 1 pts

Please note in your PDF submission that you are addressing Version #6 of this problem.

Consider the following problem:

maximize: 2.5*x + 6*y

Use the BnB calculator

subject to:

3*x + 5*y <= 26

x >= 4

x, y >=0 and integer

In your PDF submission, draw the complete branch-and-bound tree that solves this integer programming problem. Make sure to label the upper and lower bounds, the branches, the LP optimal solutions, and which nodes are fathomed and why. You can (and should!) use AMPL to help you solve the relaxed root node problem and each of the relaxed sub-problems.

For the Canvas quiz, answer the question: Including the root node, how many nodes did you explore in the B&B tree?

Question 3

1 pts

In the PDF please note that you are responding to Version #2 of this problem.

Consider the following 2D problem:

$$\min\ x_1\cos(x_1)\sin(x_2) + 0.5x_2$$

s.t.

$$-4 \le x_i \le 4 \ \text{ for } i = 1, 2$$

$$x_i \text{ integer for } i = 1, 2$$

In your PDF please answer the following questions relating to neighborhood-based search:

Start with old and rewrite eval/neighborhood function

Assume the neighborhood operator is to add or subtract 1 from either decision variable such that you typically have exactly four neighbors, i.e., (x_1 + 1, x_2), (x_1 - 1, x_2), (x_1, x_2 + 1), and (x_1, x_2 - 1).

(i) Use Hill Climbing with Best Accept (as shown in the pseudocode of the Module #10 slides "Heuristic Search", slide #44), and starting with solution (2, 2) search for the optimal solution -- please demonstrate the steps clearly in the PDF. (Note: this should take less than 5 moves to finish)

Unsure what this means

(ii) Assume that throughout a search algorithm, you identify two points A=(-1, -2) and B=(1, -4) and you want to conduct path relinking from A to B. In the PDF demonstrate the evaluations and moves from path-relinking and identify the best solution along the path. Remember, only look at solution neighbors along paths that connect A and B!

(iii) Now assume you are you using Simulated Annealing (SA). The current temperature is 3. Your current solution is (4, 0). Round to three decimal places.

Not sure what prob needs to be calculated?

- What is the probability of accepting a move from (4, 0) to candidate neighbor solution (4, 1)?
- What is the probability of accepting a move from (4, 0) to candidate neighbor solution (4,-1)?

Show your work and record your answer to part (iii) in the PDF. For the Canvas quiz, provide the SA probability to move from (4,0) to (4,-1)

Question 4

1 pts

On your PDF, please note that this exam question is for version #3.

Not hard - easier by hand

For this problem you will address questions related to binary problems (BP). Assume a 5 dimensional BP maximization problem. The leftmost bit in the encoding corresponds to variable x_1, the next bit is associated with x_2, and so on till x_5.

The evaluation function is simply: $f(\mathbf{x}) = x_1 + 2x_2 + 3x_3 + 4x_4 + 5x_5$

Your current population contains 4 chromosomes:

- 10001
- 00101
- 01011

- 11000

(i) Compute the roulette wheel selection probabilities for each chromosome. Record your answers in the PDF.

(ii) Choose the chromosome with the highest fitness and the chromosome with the lowest fitness and breed them using crossover (choose a single crossover point between the second and third bit). Determine their children and the fitness values of the children.

(iii) For the canvas quiz, please input the fitness value of the fittest child.

Question 5

1 pts

PSO easy!

Please state in the PDF that you are responding to version #2 of this question.

Use the canonical PSO velocity update and move equations for part (i) of the following maximization problem:

$$V_i^{t+1} = \omega V_i^t + \phi_1 r_1 (P_i - X_i^t) + \phi_2 r_2 (P_g - X_i^t)$$

$$X_i^{t+1} = X_i^t + V_i^{t+1}$$

where $\omega = \phi_1 = \phi_2 = 1$ and P_i and P_g are the personal and global bests, respectively.

Remember, the personal best (pBest) is the best position ever visited by a given particle, and the global best (gBest) is the best of all personal bests.

Consider the following 5 particles:

Particle ID	Positon	Velocity	Current Fitness	Personal Best Position	Personal Best Fitness
1	(14,5,2)	(1,0,1)	100	(10,13,8)	110
2	(6,4,7)	(-1,-1,0)	50	(4,7,2)	120
3	(-15,2,15)	(3,1,-2)	58	(-11,5,-4)	90
4	(8,2,9)	(1,1,1)	240	(8,2,0)	290
5	(11,8,5)	(0,0,1)	120	(18,7,5)	150

(i) Assume the values of r_1 = 0.5 and r_2 = 0.15 have been randomly generated for the current iteration. What is the next velocity and position value for particle 1 (i.e., at time t + 1)? Record your work and solution in the PDF.

(ii) Instead of using a fully connected PSO topology (i.e., a global best formulation), consider a ring topology, where particle 1 has two neighbors: particle 2 and particle 5 and use the local best (lbest) formulation, of the velocity update equation, $V_i^{t+1} = \omega V_i^t + \phi_1 r_1 (P_i - X_i^t) + \phi_2 r_2 (P_{\text{lbest}} - X_i^t)$ with $\omega = \phi_1 = \phi_2 = 1$.

Again, assume the information in the table above for time t and that the values of r_1 = 0.5 and r_2 = 0.15 have been randomly generated for the current iteration.

In this ring-topology scenario, what would be the next velocity and position value for particle 1 (i.e., at time t + 1)? Record your work and solution in the PDF and also provide the new position for particle 1 in Canvas.

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