Artificial Intelligence
Exercise Set 2

5p 1. Give the name of the algorithm that results from each of the following special cases:

a. Local beam search with k = 1 is hill-climbing search. 1p

b. Local beam search with one initial state and no limit on the number of states retained is identical to breadth-first search. 1p

c. Simulated annealing with T = 0 at all times (and omitting the termination test) is hill-climbing. 1p

d. Simulated annealing with $T = \infty$ at all times is a random-walk search: it always accepts a new state. 1p

e. Genetic algorithm with population size N = 1 means selected parents are the same individual, through crossover the same individual is obtained. Considering only a small chance of mutation, it's essentially a random walk in the space of individuals. 1p

10p 2. Read the following statements and decide whether they are true or false:

a. The major drawback of hill climbing is that it is only guaranteed to work for two-dimensional search spaces. FALSE

b. An advantage of Hill Climbing search is that it requires minimal memory. TRUE

c. Simulated annealing is a variation on hill climbing search that can prevent getting suck in local minima. TRUE

d. There exist constraint satisfaction problems that can be expressed using trinary (three-variable) constraints, but not binary constraints. FALSE

e. Simple hill climbing is a complete algorithm for solving constraint satisfaction problems. FALSE

f. Simulated annealing with a temperature T = 0 also behaves identically to a greedy hill-climbing search. TRUE NOTE: This question was poorly worded, so Jesper gave everyone credits for it.

g. Local Beam Search might find an optimal solution for a beam size k, even if it doesn't find an optimal solution for a beam size >k. TRUE

h. TabuSearch uses past experience to explore unvisited areas of the search space. TRUE

i. The probability of making a move that leads to a worse state than the current one as the temperature is decreasing in simulated annealing, is also decreasing. TRUE

j. TabuSearch and greedy hill climbing with sideways moves are equivalent. FALSE

5p 3. There are five classes running in a master's program and only three course instructors who are available to teach them. Keep in mind an instructor can only teach one class at a time. The classes are:

- Class 1 – Data Science: 8:00-9:00am.
- Class 2 - AI: 8:30-9:30am.
- Class 3 – Cloud Computing: 9:00-10:00am.
- Class 4 – Embedded AI: 9:00-10:00am.
- Class 5 - Machine Learning: 9:30-10:30am.

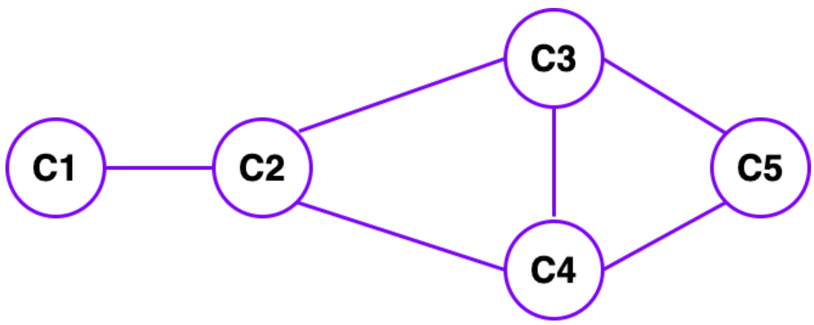
and the instructors are:

- Instructor A, who is available to teach Classes 3 and 4.
- Instructor B, who is available to teach Classes 2, 3, 4, and 5.
- Instructor C, who is available to teach Classes 1, 2, 3, 4, 5.

a. Formulate this as a CSP problem in which there is one variable per class. State the variables, their domains, and the constraints. Constraints should be unary or binary and specified formally. 1p

C1: {C}, C2: {B, C}, C3: {A, B, C}, C4: {A, B, C}, C5: {B, C}.

b. Draw the associated constraint graph. 2p



c. Show the domains of the variables after running arc-consistency on the initial graph (i.e., after having already enforced any unary constraints). 2p

C1: {C}, C2: {B}, C3: {A, C}, C4: {A, C}, C5: {B, C}

d. Give one solution. 1p

Solutions:

- C1 = C, C2 = B, C3 = C, C4 = A, C5 = B
- C1 = C, C2 = B, C3 = A, C4 = C, C5 = B

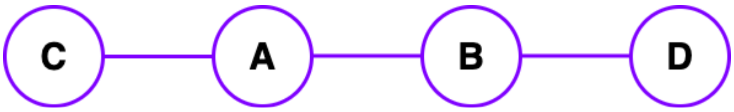
5p 4. Assume the responsibility of designing a menu for an event. The menu choices are each represented as a variable: Appetizers (A), beverages (B), main course (C), and dessert (D). The domains of the variables are listed below:

A: vegetables (v), escargot (e).
B: water (w), soda (s), milk (m).
C: fish (f), beef (b), pasta (p).
D: apple pie (a), ice cream (i), (ch) cheese platter.

Assume all guests receive the same menu, but the menu must obey the following dietary constraints:

(co1) Vegetarian options: the appetizer must be vegetables, or the main course must be pasta or fish (or both).
(co2) Total budget: if escargot is served, the budget only allows for water as a beverage option.
(co3) Dairy requirement: at least one of the following options must be served: milk, ice cream, or cheese platter.

(a) Draw the constraint graph over the variables A, B, C, and D. 2p



(b) First assign A = e. Then cross out eliminated values to show the domains of the variables after forward checking. 1p

A [e]
B [w ~~s~~ ~~m~~]
C [f ~~b~~ p]
D [a i ch]

The values s, m, and b should be crossed, s and m are eliminated due to being incompatible with e based on constraint (co2); b is eliminated due to constraint (co1).

(c) Again, first assign A = e. Then cross out eliminated values to show the domains of the variables after arc-consistency has been enforced. 1p

A [e]

B [w ~~s~~ ~~m~~]

C [f ~~b~~ p]

D [~~a~~ i ch]

The values s, m, and b should be crossed, see above. On top of that, a is crossed due to (co3).

(d) Does a solution for this CSP exist? If yes, give one. If not, explain why. 1p

One solution: A=e, B=w, C=f, and D=i.

FORWARD -CHECKING Definition:

1. One of the simplest forms of inference is called forward checking. Whenever a variable X is assigned, the forward-checking process establishes arc-consistency for it: for each unassigned variable Y that is connected to X by a constraint, delete from Y 's domain any value that is inconsistent with the value chosen for X.

OBS!!!

1. The difference between forward checking and arc-consistency is that the former only checks a single unassigned variable at time for consistency, while the second also checks pairs of unassigned variables for mutual consistency.

5p 5. Given a GA with chromosomes represented using a 5-bit string of the form $\overline{b1b2b3b4b5}$. (E.g. 001001; $b1 = 0, b2 = 0, b3 = 1, b4 = 0, b5 = 1$), its fitness function is defined over the chromosomes as below:

$$f(\overline{b1b2b3b4b5}) = b1 + b2 + b3 + b4 + b5 + AND(b1, b2, b3, b4, b5)$$

$$AND(b1, b2, b3, b4, b5) = \begin{cases} 1, if\ b1 = b2 = b3 = b4 = b5 = 1 \\ 0, otherwise \end{cases}.$$

a. Complete the table showing the probabilities of selecting each of the chromosomes below according to the standard selection method shown in class. 4p

Chromosome	Fitness	Probability of being selected
00101	2	2/14=0.14
11101	4	4/14=0.29
00000	0	0
10010	2	2/14=0.14
11111	6	6/14=0.43

b. Assume a 1-point crossover. This point has been chosen as the point between the 3rd and 4th bits. Show the two offsprings that will result from crossing over the next 2 chromosomes: 1p

011.01
101.00

Offsprings:

01100
10101