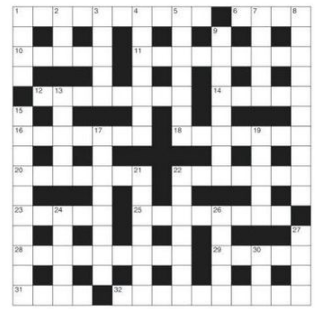
1 Multiple Choice Questions

Note: *incorrect answers will incur negative points* proportional to the number of choices. For example, a 1 point true-false question will receive 1 point if correct, -1 if incorrect, and zero if left blank. Only make informed guesses.

(a) (**1 pt**) **Who are you?** Write your name and student ID at the top of the cover page.

(b) (**1 pt each - total of 4 pts**) **Types of Agents.** You are developing an agent that solves crossword puzzles (like the one pictured to the right) using an exhaustive dictionary of possible words. States are partially completed puzzles and actions place a word on the puzzle. On each line below, we've listed two possible environmental aspects; circle the one that better describes the crossword puzzle environment.



i) fully observable vs. partially observable

ii) single agent vs. multi-agent

iii) stochastic vs. deterministic

iv) discrete vs. continuous

(c) (**1 pt each - total of 5 pts**) **True or False** Circle the correct answer.

i) T F A* search with a heuristic that is not completely admissible may still find the shortest path to the goal state.

ii) T F Doubling your computer's speed allows you to double the depth of a tree search given the same amount of time.

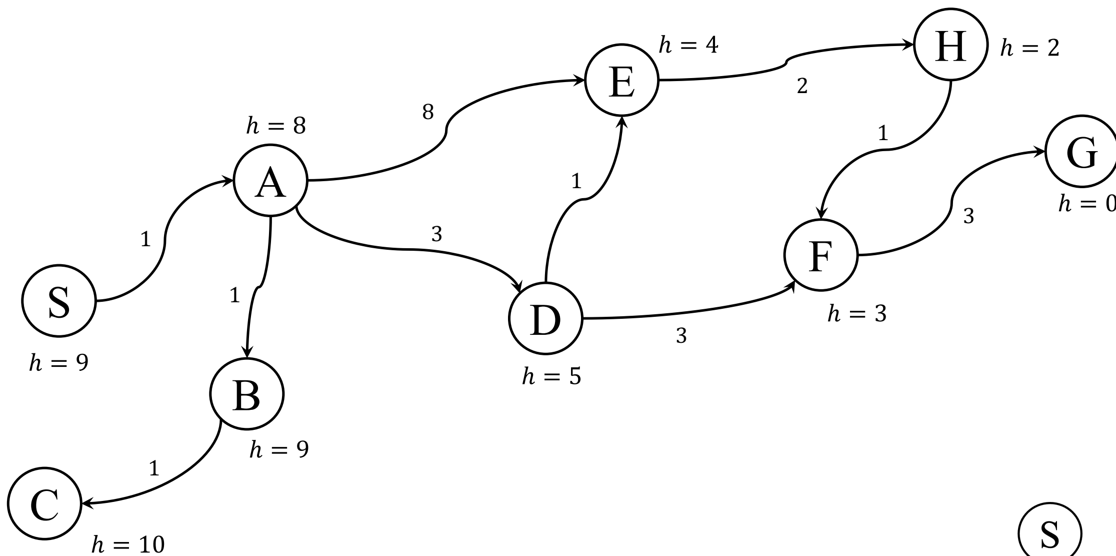
iii) T F Backtracking search on CSPs, while generally much faster than general purpose search algorithms like A*, still requires exponential time in the worst case.

iv) T F An agent that uses Minimax search, which assumes an adversary behaves optimally, may well achieve a better score when playing against a suboptimal adversary than the agent would against an optimal adversary.

v) T F For solving an integer programming problem, it is sufficient to consider the integer points around the corresponding LP solution.

2 Informed Search

Given the graph below, suppose you want to go from start state “S” to goal state “G”, write down the order in which the states are *visited* and the path found by the following search algorithms. Ties (e.g., which child to first explore in depth-first search) should be resolved alphabetically (i.e., prefer A before Z). Remember to include the start and goal states in your answer. Assume that algorithms execute the goal check when nodes are visited, not when their parent is expanded to create them as children. Do not expand any node more than once (graph search implementation).



(a) (**3 pts**) Uniform Cost Search:

Visited order: S A B C D E F H G

Solution (path length:10): S A D F G

(b) (**3 pts**) Greedy Search:

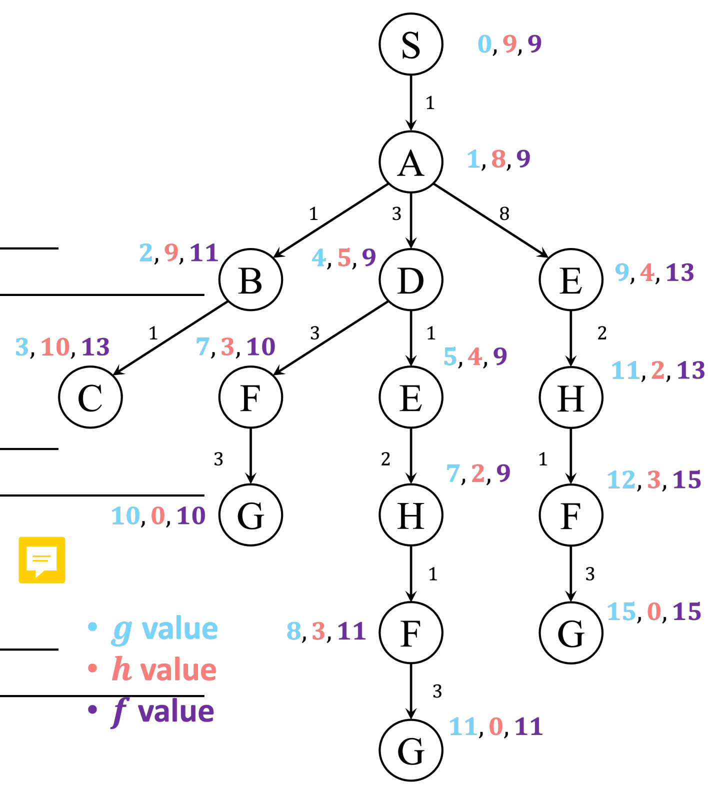
Visited order: S A E H F G

Solution (path length:15): S A E H F G

(a) (**3 pts**) A* Search (assume $f(n) = g(n) + h(n)$):

Visited order: S A D E H F G

Solution (path length:10): S A D F G



3 Course Scheduling

You are in charge of scheduling computer science classes that meet on Mondays, Wednesdays, and Fridays. There are 5 classes that meet on these days and 3 professors who will be teaching these classes. You are constrained by the fact that each professor can only teach one class at a time.

The classes are:

1. Class 1 - Intro to Programming: meets from 8:00 - 9:00 am
2. Class 2 - Intro to Artificial Intelligence: meets from 8:30 - 9:30 am
3. Class 3 - Natural Language Processing: meets from 9:00 - 10:00 am
4. Class 4 - Computer Vision: meets from 9:00 - 10:00 am
5. Class 5 - Machine Learning: meets from 10:30 - 11:30 am

The professors are:

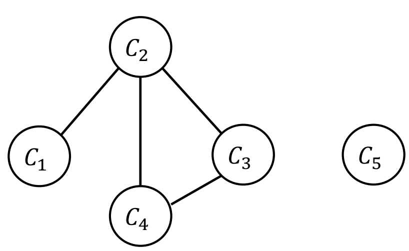
1. Professor A, who is qualified to teach Classes 1, 2, and 5.
2. Professor B, who is qualified to teach Classes 3, 4, and 5.
3. Professor C, who is qualified to teach Classes 1, 3, and 4.

(a) (**2 pts**) Formulate this problem as a CSP problem in which there is one variable per class, stating the domains, and constraints. Constraints should be specified formally and precisely, but may be implicit rather than explicit.

Variables	Domains
C_1	{A, C}
C_2	{A}
C_3	{B, C}
C_4	{B, C}
C_5	{A, B}

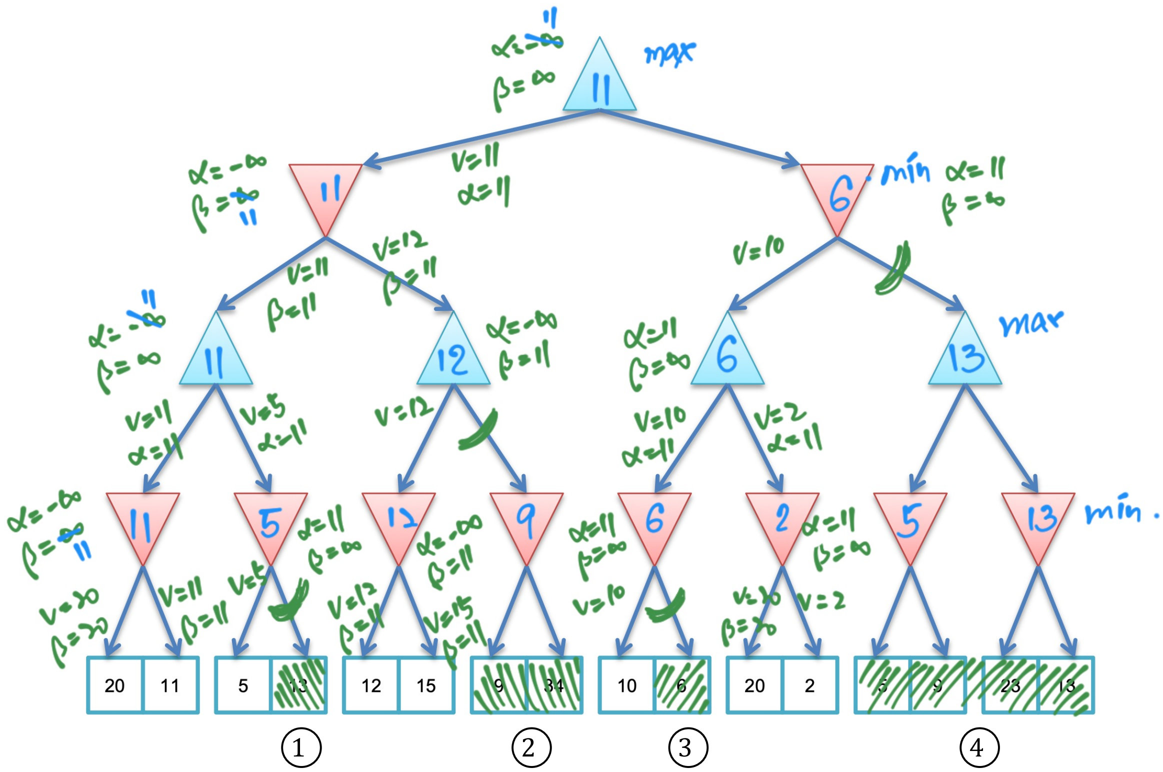
Constraints
$C_1 \neq C_2$
$C_2 \neq C_3$
$C_2 \neq C_4$
$C_3 \neq C_4$

(b) (**2 pts**) Draw the constraint graph associated with your CSP.



4 Adversarial Search

Consider the mini-max tree, whose root is a max node, shown below. Assume that children are explored left to right.



(a) (**3 pts**) Fill in the mini-max values for each of the nodes in the tree that aren't leaf nodes

(b) (**6 pts**) If α-β pruning were run on this tree, which branches would be cut? Mark the branches with a slash or a swirl (like a cut) and shade the leaf nodes that don't get explored.

initialize: $\alpha = -\infty$
$\beta = -\infty$

at max node: prune if $v \geq \beta$
else: update $\alpha = max(\alpha, v)$

at min node: prune if $v \leq \alpha$
else: update $\beta = min(\beta, v)$

prune:

①: because $(v = 5) < (\alpha = 11)$

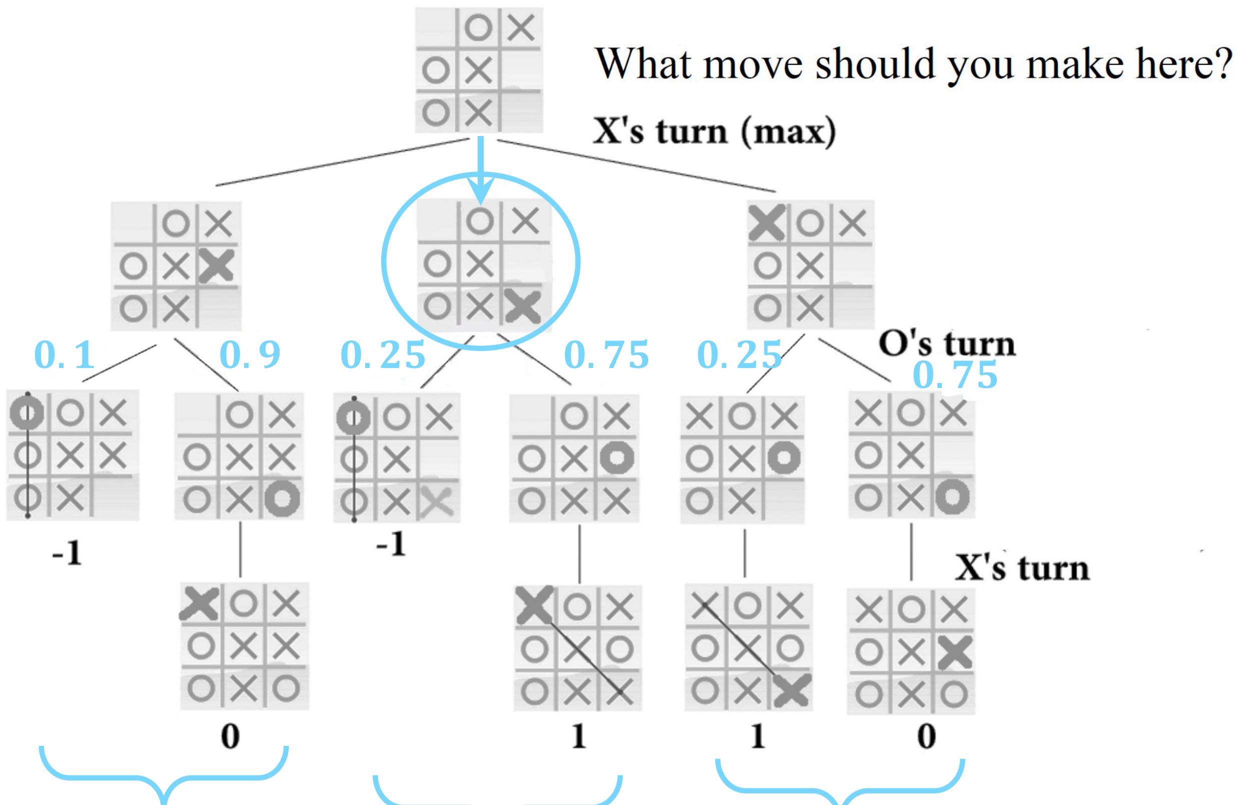
②: because $(v = 12) > (\beta = 11)$

③: because $(v = 10) < (\alpha = 11)$

④: because $(v = 10) < (\alpha = 11)$

5 Expectimax

(**4 pts**) You, are playing tic tac toe as the “X” player. You opponent, Olivia (“O” player) is a child, who is playing randomly. Since Olivia is very short, she is much more likely to fill “O”s into lower rows. Specifically, you know that Olivia is three times as likely to choose a space on the middle row than the top row, and three times again more likely to choose a space on the bottom row than the middle row. What move should you make to maximize your chance of winning? (Circle the board position and provide justifications)



$0.1\times(-1) + 0.9\times(0)$
$= -0.1$

$0.25\times(1) + 0.75\times(0)$
$= 0.25$

$0.25\times(-1) + 0.75\times(1)$
$= -0.25 + 0.75$
$= 0.5$

6 Linear Programming

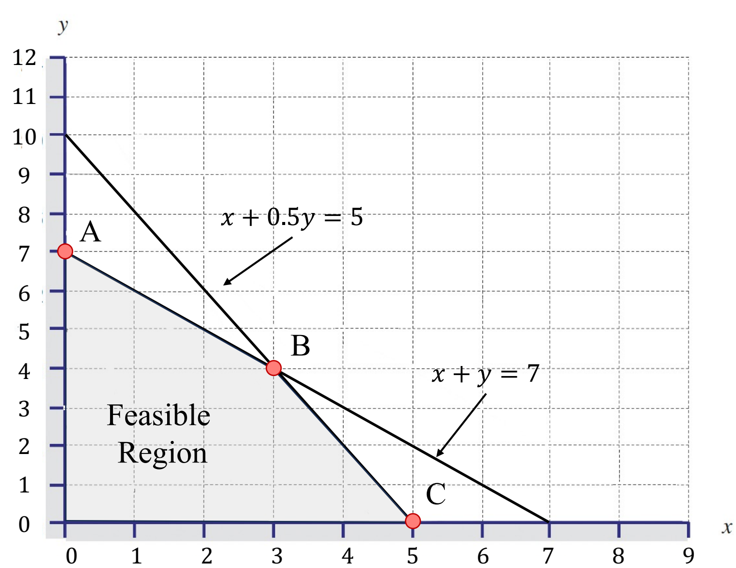
Ann and Margaret run a small business in which they work together making blouses and skirts. Each blouse takes 1 hour of Ann's time together with 1 hour of Margaret's time. Each skirt involves Ann for 1 hour and Margaret for half an hour. Ann has 7 hours available each day and Margaret has 5 hours each day. Suppose they get \$8 profit on a blouse and \$6 on a skirt. Find the number of blouses and skirts that they should make to maximize daily profit. (Note that they could just make blouses or they could just make skirts or they could make some of each. However, a partial blouse or skirt is not allowed).

(a) (**3 pts**) Formulate the problem as a linear programming problem.

$$x = \text{number of blouses to make}$$
$$y = \text{number of skirts to make}$$

$$\begin{array}{ll} \text{maximize} & P = 8x + 6y \\ \text{subject to} & x + y \leq 7 \\ & x + 0.5y \leq 5 \\ & x \geq 0, y \geq 0 \ \text{ and } \ x, y \in \mathbb{Z} \end{array}$$

(b) (**3 pts**) Draw the constraints and identify the feasible region using the provided graph below.



(c) (**3 pts**) Solve the linear programming problem you defined in (a).
Maximum profit occurs at point B ($x = 3$, $y = 4$), and the profit is given by

$$P = 8 \times 3 + 6 \times 4 = 24 + 24 = 48$$