CSci 4511
Midterm 2

Name: _____

Student ID: _____

Instructions: The time limit is 75 minutes. Please write your answers in the space below. If you need more space, write on the back of the paper. The exam is open book and notes. You may use electronic devices to ONLY look at either an e-book version or electronic notes. You may not use the internet, program/run code or any other outside resources. (If you are typing on your keyboard/input device for anything other than ctrl-F to find words in the e-book or notes, this is probably not acceptable.) For all questions you must **show work**.

Problem (1) [30 points] Find a single payoff matrix that has all of the three following properties:

- (1) The Nash equilibrium has player 1 doing action 1 40% of the time and action 2 60% of the time.
- (2) The Nash equilibrium has player 2 doing action 1 75% of the time and action 2 25% of the time.
- (3) All payoffs in the payoff matrix are unique. (i.e. two rewards cannot both be "4" but it is okay to have one reward "1" and another reward "11".)

Problem (2) [20 points] Answer the following questions about alpha-beta pruning. For both parts assume at every level of the tree, the actions/edges will be searched from the leftmost to the rightmost.

(1) Find a specific example of a tree where if you apply alpha-beta pruning, you can prune 70% or more of the leaves. (Note: this should **not** be a general description of a tree.)

(2) On your example tree from part (1), find a different configuration of the same tree where you can prune the least possible amount of leaves. (Note: as this must be the same tree, the structure of the tree must still be equivalent. Simply swap actions/edges to search them differently when going left to right.)

Problem (3) [20 points] `Sudoku Rules:`
Sudoku is a game where you try and fill in numbers such that each sub-box, row and column all have unique digits. Sub-boxes never overlap. The digits are always 1 to the width of the board. Figure 1a shows a solution for a 4x4 Sudoku problem. For 4x4 Sudoku there are four 2x2 "sub-boxes": one in the top-right, one in the top-left, one in the bottom-right and one in the bottom-left. For example, the top-left sub-box in Figure 1a is the $(1, 2)$ along with the $(3, 4)$ right below the $(1, 2)$. If you still have questions on the goal of Sudoku, please ask.

`Problem:`
Your starting problem is shown in Figure 1b. There are two 1's and one of each 2, 3 and 4 filled in the board already. Letters are in the blank/unknown spots. This question will focus on the top-left sub-box involving (A, 1) and (D, E) for the Sudoku board in Figure 1b:

(1) Write down the constraints using letters and numbers to formulate the Sudoku problem shown in Figure 1b as a constraint satisfaction problem. Show **only** the constraints involved in the top two rows, the left two columns and the top-left sub-box to ensure the rules of Sudoku are followed.

(2) Show the initial domains for letters $\{A, D, E\}$ that are valid for the initial board.

(3) Find the domains of the letters $\{A, D, E\}$ that are 2-consistent with each other. (Please be clear on how you are reaching 2-consistency.)

(Note: please write your answers on the next page, which is blank.)

1	2	3	4
3	4	1	2
2	1	4	3
4	3	2	1

(a) A sample solution for a 4x4 Sudoku board

A	1	B	C
D	E	1	2
F	4	G	3
H	I	J	K

(b) Problem 4's Sudoku problem

Figure 1: 4x4 Sudoku

Problem 3 answers:

Problem (4) [30 points] Consider the following sentences:
$A \Rightarrow B$
$\neg B \Rightarrow \neg C$
$\neg A \Rightarrow B$
$B \Rightarrow (\neg C \vee A)$

(1) Do the sentences above entail: $B \vee C$?

(2) Do the sentences above entail: $A \vee C$?