CSci 4511
Midterm 2

Instructions: The time limit is 75 minutes. Please write your answers on a separate piece of 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 if you **show work** you are more likely to receive partial credit for incorrect answers.

Problem (1) [25 points] Consider the following game, where the row player is player 1 and the rewards are in the format (player 1, player 2):

Table 1: Problem 1 game

	Action 1	Action 2
Action 1	(1, 5)	(10, 10)
Action 2	(0, 0)	(5, 1)

(1) (5 points) What are the pure Nash equilibrium points?
(2) (5 points) What are the Pareto optimal points?
(3) (5 points) Is this a zero sum game?
(4) (10 points) Is it possible to have more Nash equilibrium points than Pareto optimal points? (Not necessarily on the game shown above.)

Problem (2) [15 points] It takes 120 minutes to fly from MSP to YYZ. Assume the plane ascends/descends at a rate of 500 m/min. The maximum cruise height is $12,000$ m and minimum safe cruise height is $6,000$ m. Using these flight statistics, answer the following questions:
(1) (5 points) Graph the viable flight altitudes along the course of the plane ride (x-axis is time, y-axis is altitude). Show the viable area using a darker shade.
(2) (10 points) There is turbulence above $10,000$ meters starting 50 minutes into the flight and ending at 75 minutes into the flight. During this period, the plane should not fly in the turbulence. We also do not want to change cruising altitudes unless we can cruise for at a minimum 20 minutes at that height. What is the highest flight path that follows all of these conditions?

(MORE ON THE OTHER SIDE)

Problem (3) [25 points] Answer the following questions about mini-max, alpha-beta pruning and pruning in general:
(1) (5 points) Does the order you choose actions for states in the tree change how much you can prune?
(2) (10 points) Suppose you have a full binary tree (each node has 2 children and all leaves are on the same depth). You (a maximizer) are playing against an opponent (a minimizer). Assume the game is zero-sum, but you do not know the values of the terminal/leaf states. With the most efficient pruning possible, what is the maximum amount of terminal/leaf states you do not need to consider?
(3) (10 points) Chess has 3 possible terminal/leaf states: value 1 = win for you, value -1 = loss for you, value 0 = tie (this makes it a zero sum game). The large depth makes it too prohibitive to run mini-max directly. Describe how you can prune and fully explain the implications.

Problem (4) [20 points]
Alice, Bob, Catherine and Darwin are going on a road trip in a 4 seat car (driver's seat, front right, back left, back right). Only Alice and Darwin have driver's licenses. Darwin is very tall and Bob has a bad knee, so they both need more leg room, meaning they cannot sit in front/behind of each other. Catherine likes to sit on the right side of the car. Everyone likes to have their own seat (no sitting on laps).
(1) (5 points) Apply all unary constraints and show the resulting domains.
(2) (5 points) If we were to do a efficient backtracking search, which variable should we try to assign a value to first?
(3) (10 points) Perform a backtracking search to find a valid seating configuration. Show the tree as search.

Problem (5) [15 points] Consider the following sentences that form our knowledge base (KB):
$A \vee B \Rightarrow C \vee D$
$\neg C \vee D$
$A \vee C$
(1) (5 points) Convert these sentences to CNF.
(2) (5 points) Use resolution to see if: $KB \models C$
(3) (5 points) Use resolution to see if: $KB \models D$