Name: ______________________________________
Student ID: ______________________________________

CSE 473 Autumn 2012: Midterm Exam SOLUTIONS

(closed book, closed notes except for 1-page summary)

Total: 100 points, 5 questions. Time: 50 minutes

Instructions:

1. Write your name and student ID on the first sheet (once you start, write your last name on all sheets). Write your answers in the space provided. If you need more space or scratch paper, you can get additional sheets from the instructor. Make sure you write down the question number and your name on any additional sheets.
2. Read all questions carefully before answering them. Feel free to come to the front to ask for clarifications.
3. *Hint 1*: You may answer the questions in any order, so if you find that you're having trouble with one of them, move on to another one.
4. *Hint 2*: If you don't know the answer to a question, don't omit it - do the best you can! You may still get partial credit for whatever you wrote down. Good luck!

Do not start until you are given the "go-ahead signal"…

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1) **(20 points, 10 each) Agents and Environments**
   a) Give a PEAS description of the task environment for the following agents:
      i) A mobile robot that delivers coffee in an office building
      ii) A crossword puzzle solver
   b) For each of the agents above, characterize the environment according to whether it is fully or partially observable, deterministic or stochastic, episodic or sequential, static or dynamic, discrete or continuous, and single or multiagent.

a) performance measure, environment, actuators, sensors

	P	E	A	S
i)	delivery or not speed lack of mess	people moving walls & furniture people talking	wheels arms voice	cameras bumpers lasers microphones haptics on hands
ii)	clues figured out	internet (for reading) API for outputting answers and maybe getting feedback	(none)	(none)

b)
i) partially observable; stochastic; sequential assuming there's no unique state to return to after each fetch; dynamic; continuous; multiagent

ii) (talking about the puzzle, not the internet) fully observable; deterministic; sequential in general due to dependence on previous fill-ins; static; discrete; single-agent

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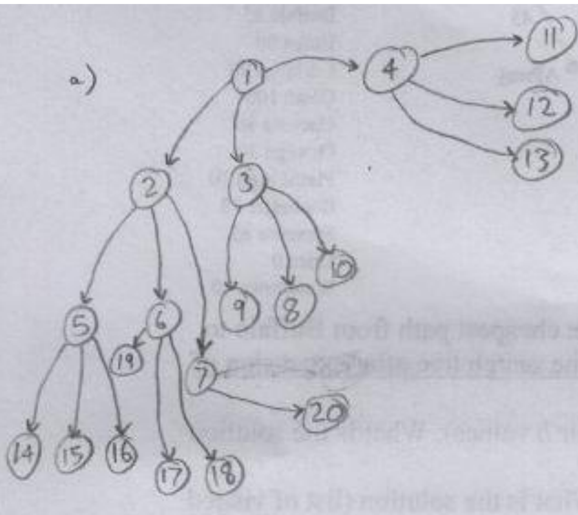
2) (20 points, 5 for a, 15 for b) Uninformed Search

Consider a state space where the start state is 1 and the successor function for state *i* (where *i* = 1, 2, …) returns three states: 3*i*-1, 3*i*, 3*i*+1.

a) Draw the state space graph for states 1 to 20.

b) Suppose the goal state is 17. List the order in which nodes will be visited for: (i) breadth-first search, (ii) depth-limited search with depth limit 2, and (iii) iterative deepening search.

a)



b) BFS: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17

DL-DFS(2): 1, 2, 5, 6, 7, 3, 8, 9, 10, 4, 11, 12, 13

ID-DFS: 1, 1, 2, 3, 4, 1, 2, 5, 6, 7, 3, 8, 9, 10, 4, 11, 12, 13, 1, 2, 5, 14, 15, 16, 6, 17

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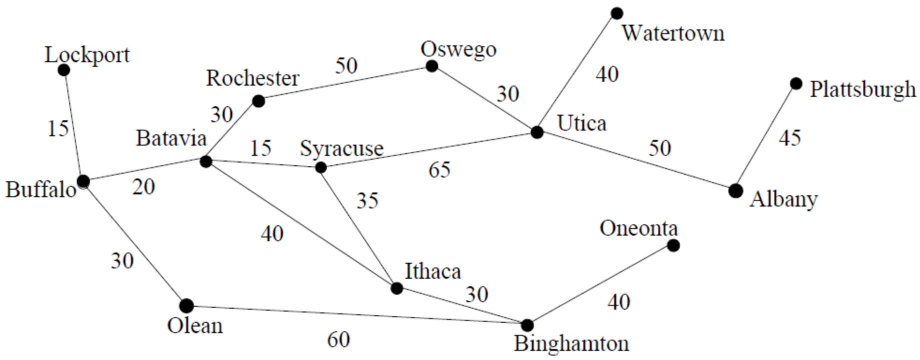
3) (20 points, 10 each) Informed Search

The map below shows the routes through various towns in the state of New York. The route distances are labeled on the edges between towns. The table on the right gives the straight line distances from Utica to the other towns.



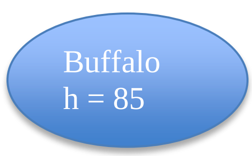
Distance from Utica:
Albany 50
Batavia 75
Binghamton 110
Buffalo 85
Ithaca 90
Lockport 90
Olean 100
Oneonta 80
Oswego 30
Plattsburgh 70
Rochester 55
Syracuse 65
Utica 0
Watertown 40

Consider the route-finding problem of computing the cheapest path from Buffalo to Utica. For the straight-line distance heuristic, <u>draw the search tree after expansion of each node</u> until the termination of the algorithm for:

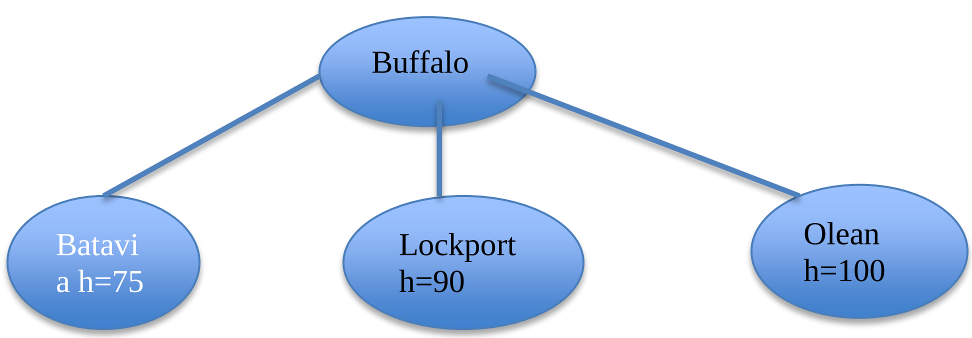
See Lecture 4 slides.

a) Greedy best-first search (label all nodes with their *h* values). What is the solution (list of visited cities) found by the algorithm?

0)



1)



Name: ______________________________
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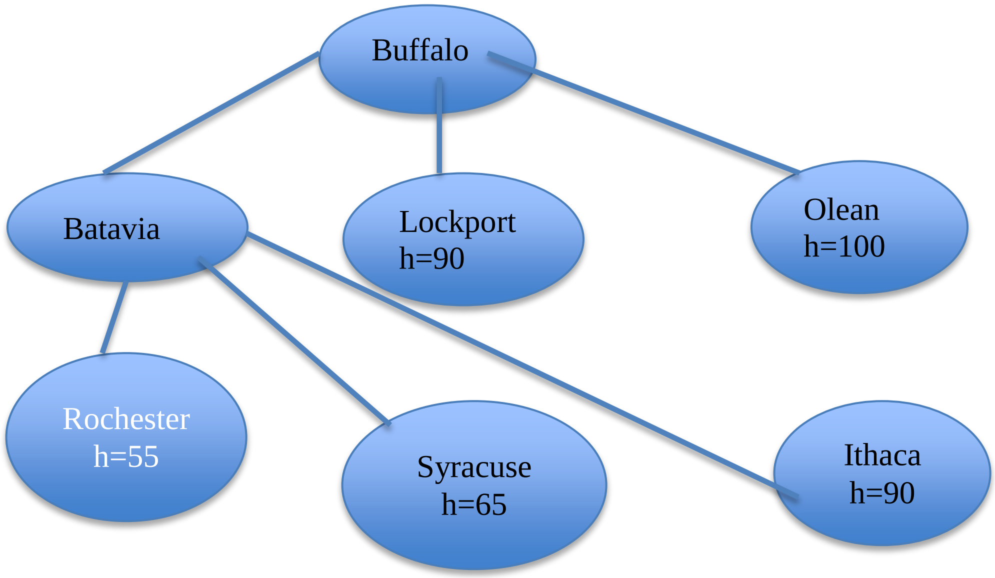
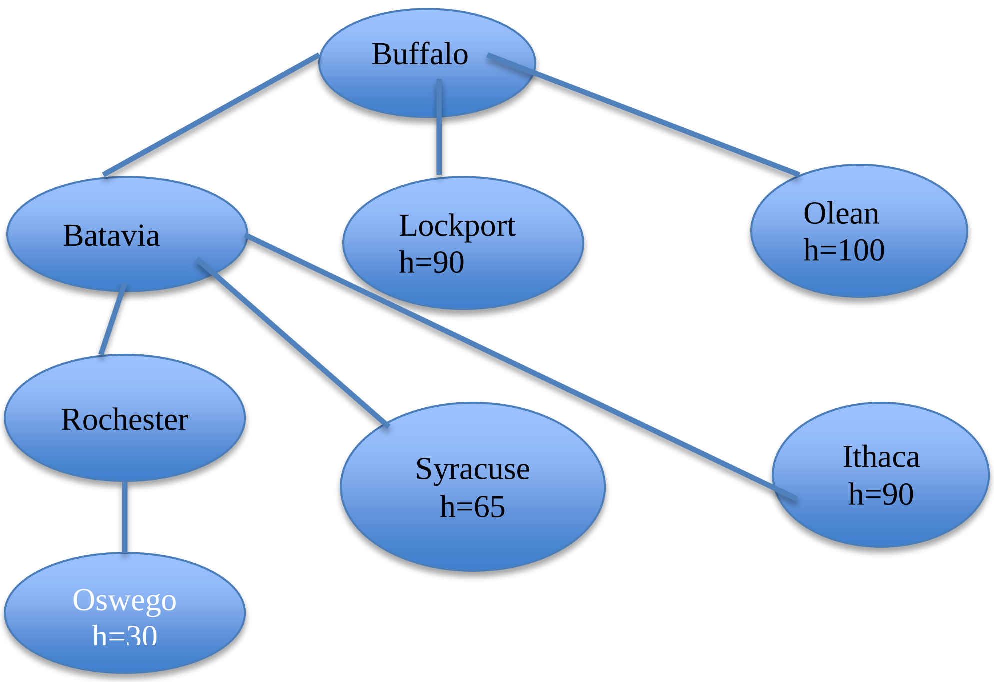
2)



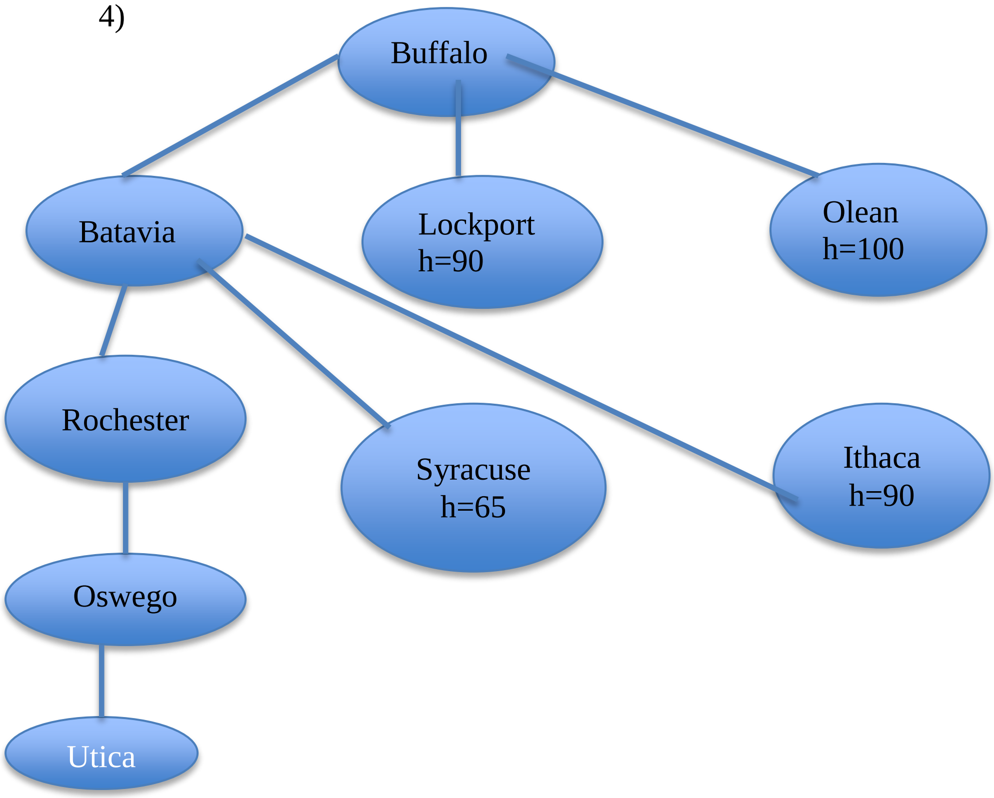
3)



Name: ______________________________

Student ID: ______________________________

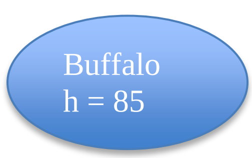
4)



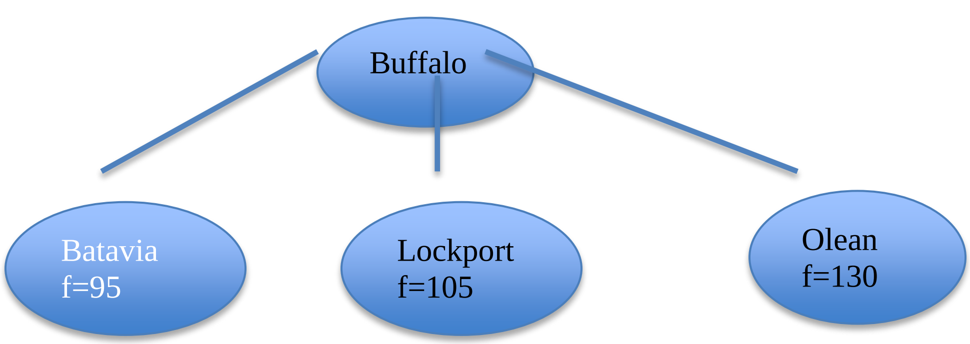
Solution: Buffalo, Batavia, Rochester, Oswego, Utica

b) A* search (label all nodes with their *f* values). What is the solution (list of visited cities) found by the algorithm?

0)

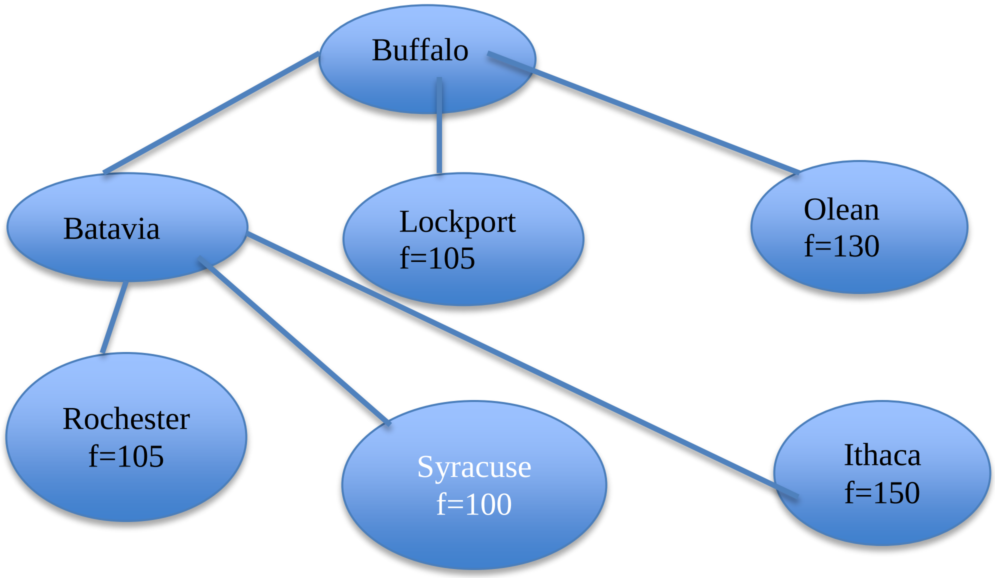


1)

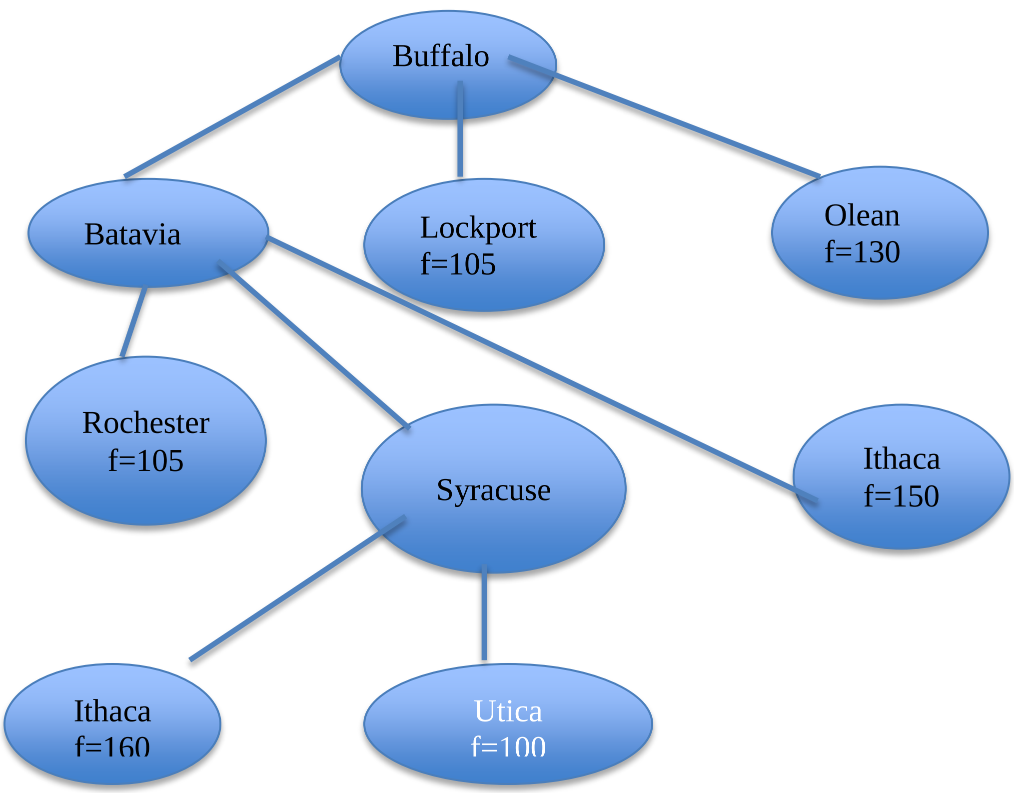


Name: ___________________________________
Student ID: ___________________________________

2)



3)



Solution: Buffalo, Batavia, Syracuse, Utica

Name: ______________________________________

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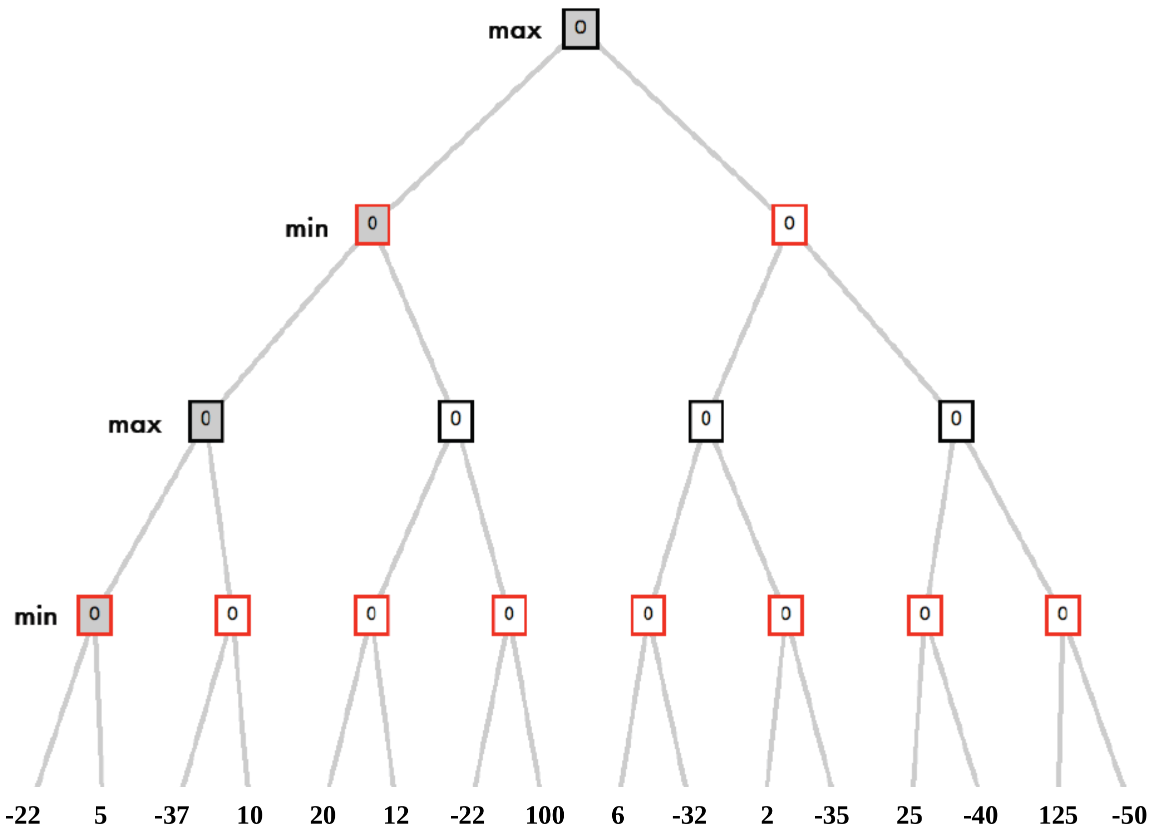
4) (15 points, 5 each) Adversarial Search

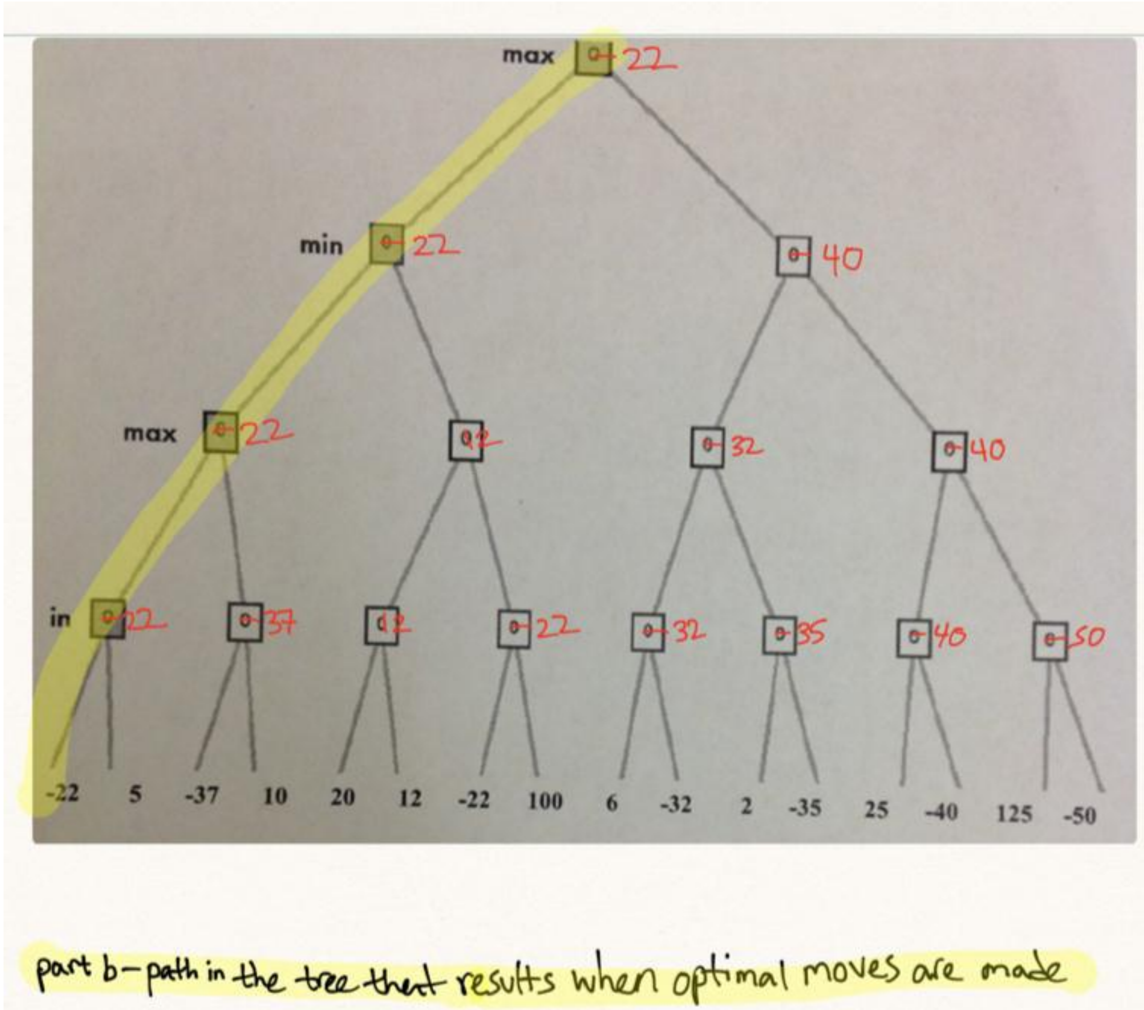


Consider the 4-ply game tree above for a two-person game.

a) Fill in the minimax values of all nodes marked 0 in the tree above.

b) Label the path in the tree that results if max and min each make optimal moves.

Name: ______________________________
Student ID: ______________________________



Name: ______________________________________
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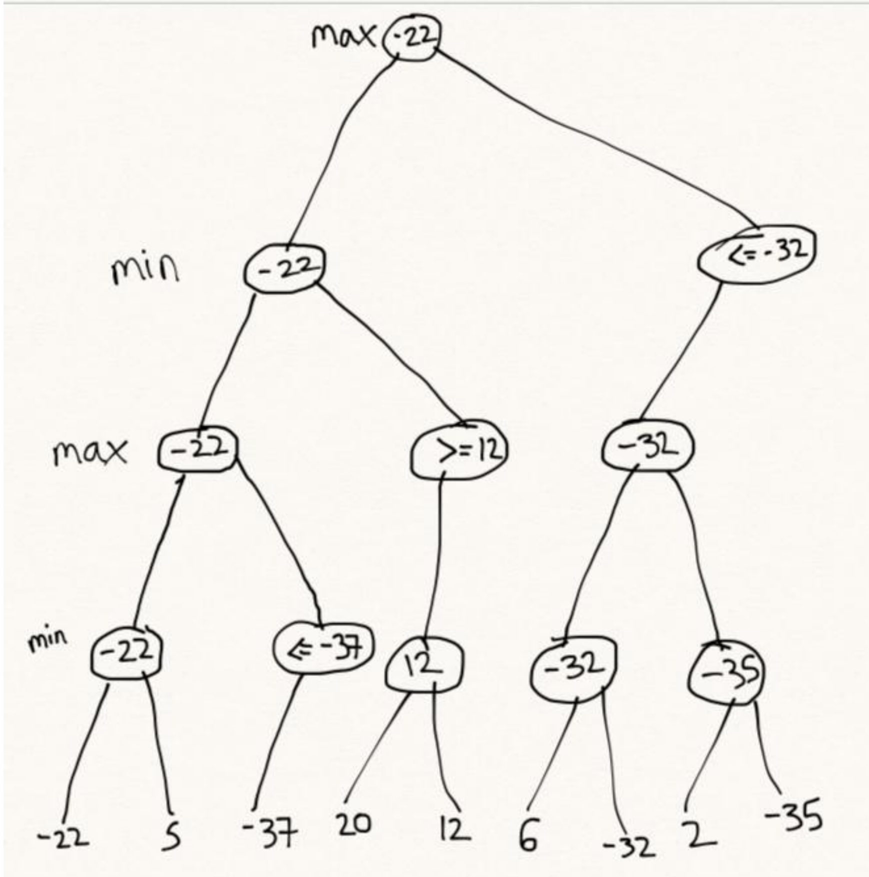
c) Draw the tree that results if alpha-beta pruning is used. (Use the space below or the opposite blank page)



Name: ____
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(25 points, 10 for a, 15 for b) Propositional and First-Order Logic

d) State whether each of the following sentences in propositional logic is valid, satisfiable but not valid, or unsatisfiable. Explain your answer.

i) $\neg (A \Rightarrow A)$
unsatisfiable

ii) $A \vee B \vee (A \Rightarrow B)$
valid

A	$A \Rightarrow A$	$\neg (A \Rightarrow A)$
T	T	F
F	T	F

A	B	$A \Rightarrow B$	$A \vee B \vee (A \Rightarrow B)$
T	T	T	T
T	F	F	T
F	T	T	T
F	F	T	T

See lecture 10 slides.

A sentence is:

- *valid* if it is true in all models
-*satisfiable* if it is true in some model
-*unsatisfiable* if it is true in no models

From TT enumeration we can see that 5.a.i is always false; thus it is unsatisfiable. Similarly 5.a.ii is always true, so it is valid.

e) Suppose a knowledge base contains the following sentences in first-order logic.

i) Convert the sentences above to CNF.
See lecture 13, page 2.

(1) $\forall x\ [\forall y\ A(x,y) \wedge B(y,x)] \Rightarrow C(x)$
$\neg A(x, F(x)) \vee \neg B(F(x),x) \vee C(x)$

(2) $\forall x \forall y\ [\neg C(x) \Rightarrow A(x,y)]$
$C(x) \vee A(x,y)$

(3) $\forall x\ B(x,\text{diddy})$ (where diddy is a constant symbol)
$B(x,\text{diddy})$

Name: ________________________________
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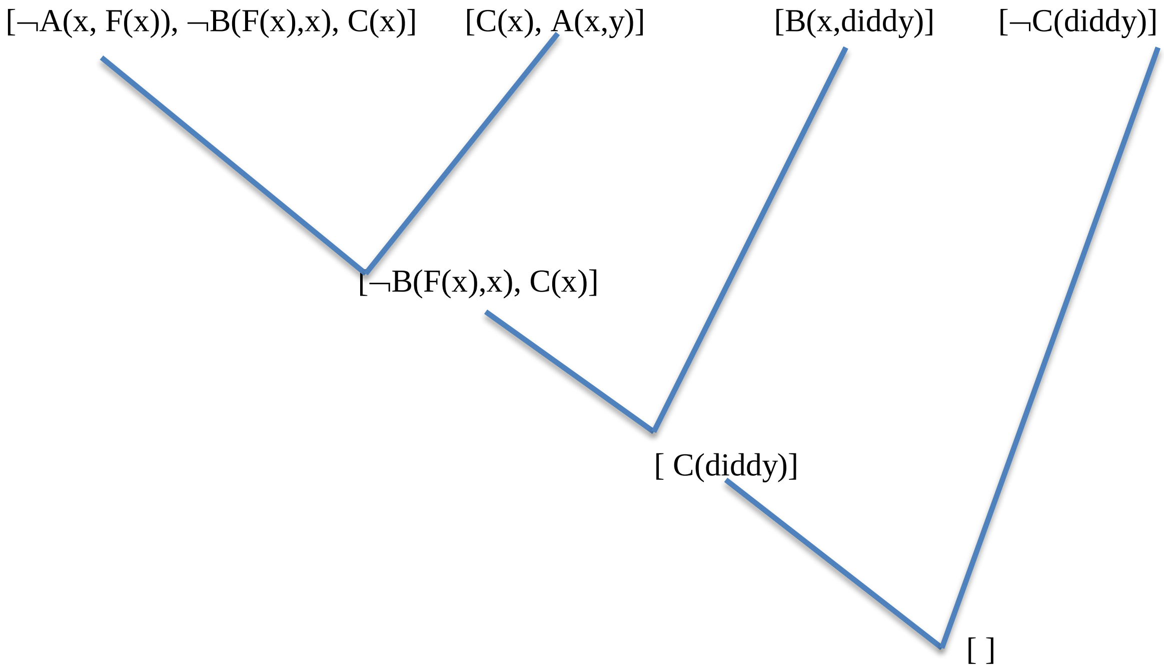
ii) Using your CNF sentences in (i), construct a resolution proof that *C*(diddy).

See lecture 13, pages 12-13. Similar to slides, use ‘proof by contradiction’ to show C(diddy) by showing KB ∧ ¬C(diddy) is unsatisfiable.



As we’ve reached an empty clause, this is unsatisfiable. Therefore by contradiction, C(diddy) is holds.