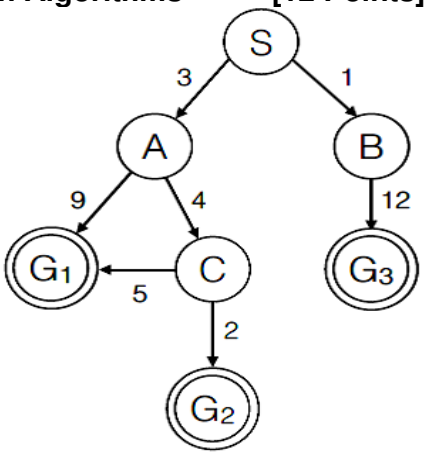
Student ID _____

National University of Computer and Emerging Sciences, Lahore Campus

	Course:	**Artificial Intelligence**	**Course Code:**	**CS101**
	Program:	**BS(CS)**	**Semester:**	**Fall 2016**
	Duration:	**180 Minutes**	**Total Marks:**	**60**
	Paper Date:	**21 Dec 2016**	**Weight**	
	Section:	**ALL**	**Page(s):**	**10**
	Exam:	**Final**	**Reg. No.**	

Instruction/Notes: Solve the exam on this question paper.

Problem 1 Search Algorithms [12 Points]



	A	B	C	S
H-1	0	0	0	0
H-2	6	7	1	7
H-3	7	7	1	7
H-4	4	7	1	7

(a) Consider the search graph and heuristics shown above. Select all of the goals that could be returned by each of the search algorithms below. For this question, if there is a tie on the fringe, assume the tie is broken randomly.

(i) [1 pt] DFS G_1 ○ G_2 ○ G_3 ○

(ii) [1 pt] BFS G_1 ○ G_2 ○ G_3 ○

(iii) [1 pt] UCS G_1 ○ G_2 ○ G_3 ○

(iv) [1 pt] Greedy with H-1 G_1 ○ G_2 ○ G_3 ○

(v) [1 pt] Greedy with H-2 G_1 ○ G_2 ○ G_3 ○

(vi) [1 pt] Greedy with H-3 G_1 ○ G_2 ○ G_3 ○

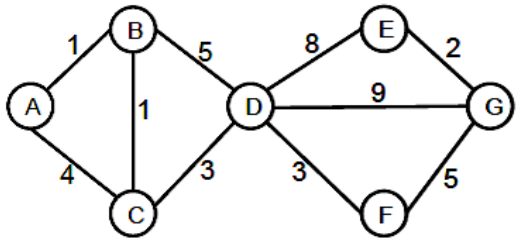
(vii) [1 pt] A* with H-2 G_1 ○ G_2 ○ G_3 ○

(viii) [1 pt] A* with H-3 G_1 ○ G_2 ○ G_3 ○

(b) For each heuristic, indicate whether it is consistent, admissible, or neither (select more than one option if
appropriate):

(i) [1 pt] H-1	**Consistent** ○	**Admissible** ○	**Neither** ○
(ii) [1 pt] H-2	**Consistent** ○	**Admissible** ○	**Neither** ○
(iii) [1 pt] H-3	**Consistent** ○	**Admissible** ○	**Neither** ○
(iv) [1 pt] H-4	**Consistent** ○	**Admissible** ○	**Neither** ○

Problem 2 Search Algorithms



Node	h_1	h_2
A	9.5	10
B	9	12
C	8	10
D	7	8
E	1.5	1
F	4	4.5
G	0	0

Consider the state space graph shown above. A is the start state and G is the goal state. The costs for each edge are shown on the graph. Each edge can be traversed in both directions. Note that the heuristic h1 is consistent but the heuristic h2 is not consistent.

Part a **[4 Points]**

For each of the following graph search strategies (do not answer for tree search), mark which, if any, of the listed paths it could return. Note that for some search strategies the specific path returned might depend on tie-breaking behavior. In any such cases, make sure to mark all paths that could be returned under some tie-breaking scheme.

Search Algorithm | Path	**A-B-D-G**	**A-C-D-G**	**A-B-C-D-F-G**
Uniform cost search			
A* search with heuristic h1			
A* search with heuristic h2			

(b) **[6 Points]**

Suppose you are completing the new heuristic function h3 shown below. All the values are fixed except $\mathbf{h_3(B)}$.

Node	A	B	C	D	E	F	G
h3	10	?	9	7	1.5	4.5	0

For each of the following conditions, write the set of values that are possible for h3(B). For example, to denote all non-negative numbers, between 0 and 1 write [0, 1], to denote the empty set, write **None**.

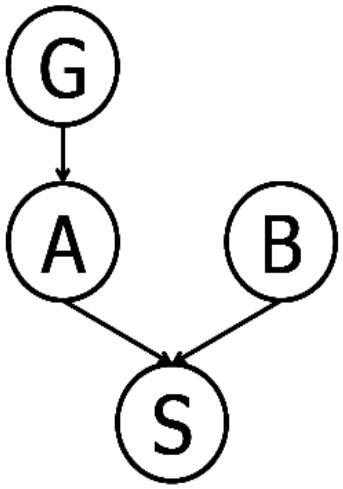
(i) What values of h3(B) make h3 admissible?

(ii) What values of h3(B) make h3 consistent?

(iii) What values of h3(B) will cause A* graph search to expand node A, then node C, then node B, then node D in order?

$\mathbb{P}(G)$	
$+g$	0.1
$-g$	0.9

$\mathbb{P}(A\|G)$		
$+g$	$+a$	1.0
$+g$	$-a$	0.0
$-g$	$+a$	0.1
$-g$	$-a$	0.9



$\mathbb{P}(B)$	
$+b$	0.4
$-b$	0.6

$\mathbb{P}(S\|A,B)$			
$+a$	$+b$	$+s$	1.0
$+a$	$+b$	$-s$	0.0
$+a$	$-b$	$+s$	0.9
$+a$	$-b$	$-s$	0.1
$-a$	$+b$	$+s$	0.8
$-a$	$+b$	$-s$	0.2
$-a$	$-b$	$+s$	0.1
$-a$	$-b$	$-s$	0.9

Problem 3 **[12 Points]**

Suppose that a patient can have a symptom (S) that can be caused by two different diseases (A and B). It is known that the variation of gene G plays a big role in the manifestation of disease A. The Bayes' Net and corresponding conditional probability tables for this situation are shown For each part, you may leave your answer as an arithmetic expression.

(a) Compute the following entry from the joint distribution:

P(+g;+a;+b;+s) =

(b) What is the probability that a patient has disease A?

$P(+a) =$

(c) What is the probability that a patient has disease A given that they have disease B?

$P(+a \mid +b) =$

(d) What is the probability that a patient has disease A given that they have symptom S and disease B?

$P(+a \mid +s;+b) =$

(e) What is the probability that a patient has the disease carrying gene variation G given that they have disease A?

$P(+g \mid +a) =$

(f) What is the probability that a patient has the disease carrying gene variation G given that they have disease B?

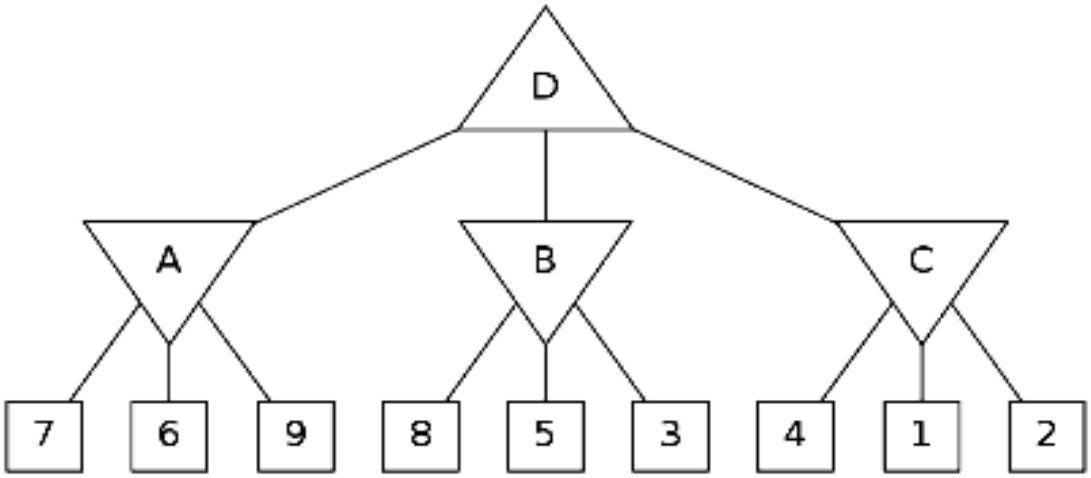
$P(+g \mid +b) =$

Problem 4 Minimax with alpha-beta pruning

Consider the game tree shown below. Triangles that point up, such as at the top node (root), represent choices for the maximizing player; triangles that point down represent choices for the minimizing player. Assuming both players act optimally, use alpha-beta pruning to find the value of the root node. The search goes from left to right; when choosing which child to visit first, choose the left-most unvisited child.

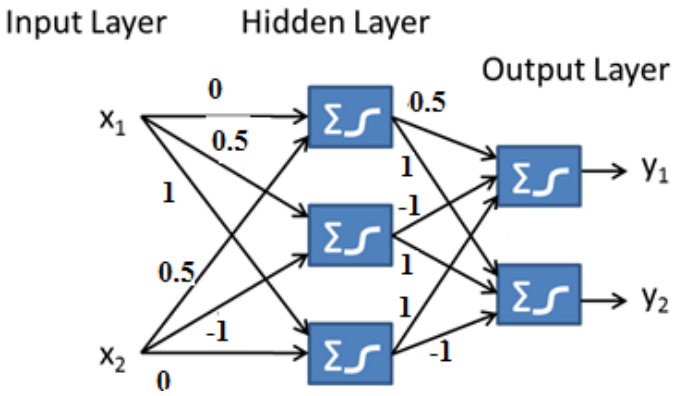
Specify the value of each of the node as computed by the MINIMAX algorithm and also specify the nodes that will be pruned by the alpha-beta pruning strategy **[4 + 4 Points]**

Hint: Note that the value of a node where pruning occurs is not necessarily the maximum or minimum (depending on which node) of its children. When you prune on conditions $V>\beta$ or $V<\alpha$, assume that the value of the node is



Problem 5 Learning a feed-forward ANN **[10 Points]**

Consider the neural network architecture with two inputs **(x_1, x_2)** three hidden layer neurons and two output neurons (***Y_1, Y_2***). Assume that each neuron has a bias term set equal to -1 and each neuron uses the sigmoid activation function given as $f(x) = \frac{1}{1+e^{-x}}$



Weights of all neurons as shown on the figure are

Hidden Neurons

Top Neuron	**0**	**0.5**
Middle Neuron	**0.5**	**-1**
Bottom Neuron	**1**	**0**

Output Neurons

Top Neuron	**0.5**	**-1**	**1**
Bottom Neuron	**1**	**1**	**-1**

For the training example with input $\boldsymbol{X}$ = [2, -2] and Target $\boldsymbol{Y}$ = [1, 0]

i. Compute Output: **[3 Points]**

compute the neural network output where α = 1

ii. Error Calculation and Back Propagation. **[3 + 4 Points]**

a. For each of the output neurons, compute the error term $\boldsymbol{\delta_k}$ used by the back-propagation algorithm to update the weights.

b. Compute the error term $\boldsymbol{\delta_h}$ for each of the hidden neurons.

Problem 6 Perceptron Learning **[4 + 4 points]**

You have decided to become a teacher. The only issue is that you don't want to spend lots of time grading essays, so instead you decide to grade them all with a linear classifier. Your classifier considers the number of 7-letter (f7) and 8-letter words (f8) in an essay and then assigns a grade, either A or F, based on those two numbers. You have four graded essays to learn from:

$BIAS$	f_7	f_8	grade
1	2	1	A (+)
1	0	2	F (-)
1	1	2	A (+)
1	1	0	F (-)

You decide to run perceptron learning rule to learn the weights of a perceptron and being optimistic about the students essay writing capabilities, you decide to initialize your weight vector as (1; 0; 0). If the score from your classifier is greater than 0, it gives an A, if it is 0 or lower, it gives an F. Fill in the resulting weight vector after having seen the first training example and after having seen the second training example.

	BIAS	f_7	f_8
Initial	1	0	0
After first training example			
After second training example			

Part b) For each of the following decision rules, indicate whether there is a weight vector (a perceptron) that can represent the decision rule. If your answer is **"Yes"** then show such a weight vector.

1. A paper gets an A if and only if it satisfies (f7 + f8 > 7).

2. A paper gets an A if and only if it satisfies (f7 > 5 AND f8 > 4).

3. A paper gets an A if and only if it satisfies (f7 > 5 OR f8 > 4).

4. A paper gets an A if and only if it has between 4 and 6, inclusive, 7-letter words and between 3 and 5 8-letter words.