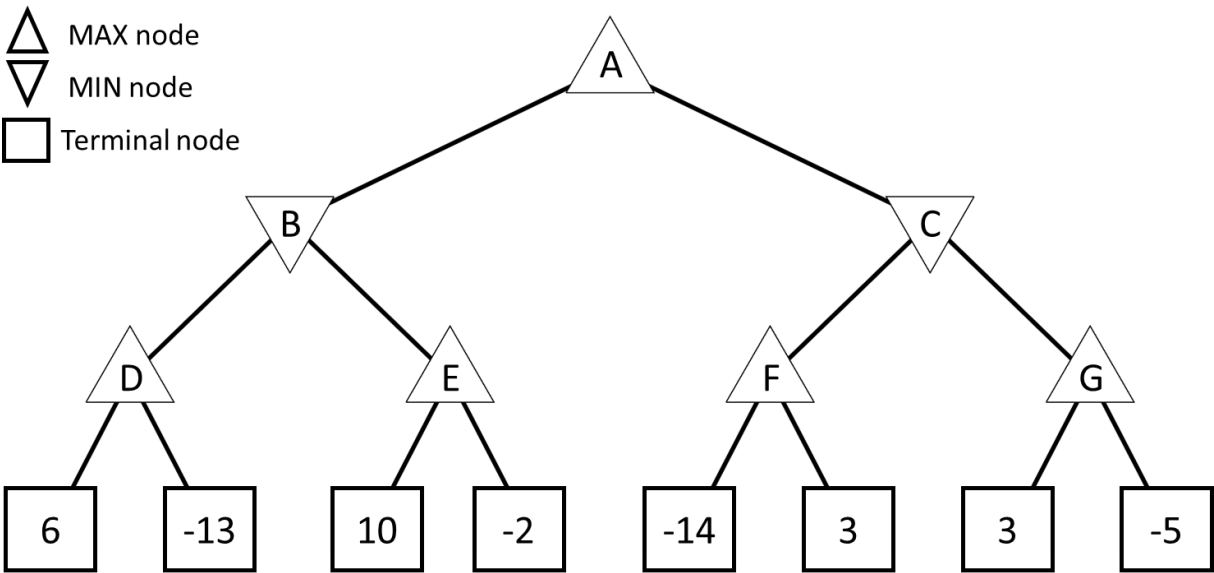**King Fahd University of Petroleum and Minerals**
College of Computing and Mathematics
Information and Computer Science Department

ICS 381: **Principles of Artificial Intelligence**
Spring Semester 2024-2025
Quiz#2, Tuesday, April 8th 2025

Name:

ID:

I.   [14 points] Game Playing I

Utility at terminal nodes are for the MAX player. For the game-tree above, apply **minimax with alpha- beta pruning**. Process nodes in **left-to-right** order. **After** you are done, provide answers for the following questions.

a) For node **D**, give the following quantities: (If pruned, then write **pruned** as an answer)

value = ___6___ $\alpha =$ ___6___ $\beta =$ ___∞___

b) For node **E**, give the following quantities: (If pruned, then write **pruned** as an answer)

value = ___10___ $\alpha =$ ___10___ $\beta =$ ___6___   **Pruned**

c) For node **C**, give the following quantities: (If pruned, then write **pruned** as an answer)
value = ___3___ $\alpha =$ ___6___ $\beta =$ ___3___   **Pruned**

d) For node **F**, give the following quantities: (If pruned, then write **pruned** as an answer)
value = ___3___ $\alpha =$ ___3___ $\beta =$ ___∞___

e) For node **G**, give the following quantities: (If pruned, then write **pruned** as an answer)
value = ___pruned___ $\alpha =$ ___pruned___ $\beta =$ ___pruned___

f) For the alpha-beta algorithm, how many extra variables (compared to minimax) are we maintaining for each game-node?
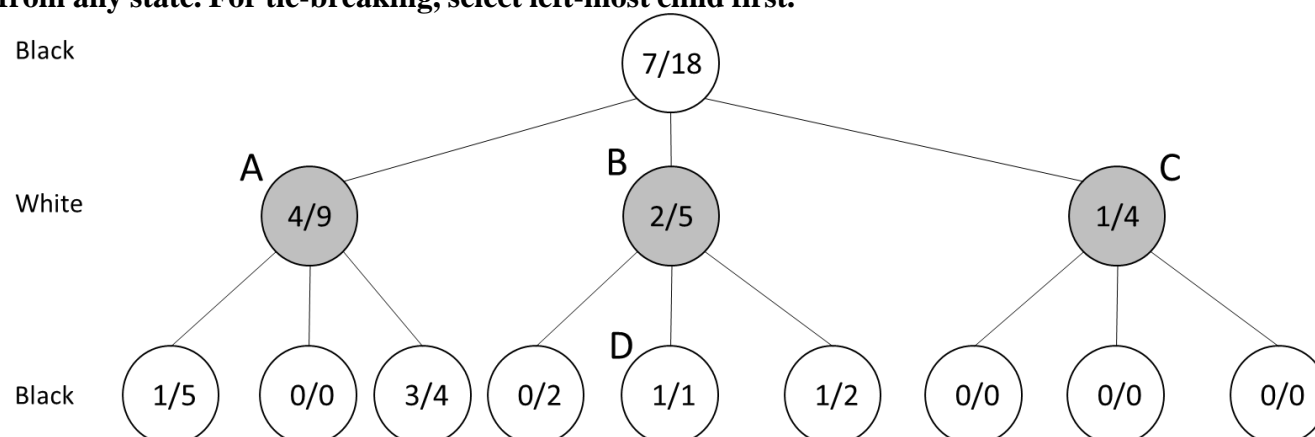   Answer: ___2___

g) Consider game with $O(b)$ branching and $O(d)$ turns. Which of the following choices best captures the worst-case time-complexity of alpha-beta algorithm?

    a) $O(b)$
    b) $O(b^{22})$
    c) $O(bd)$
    d) $O(b^{d/22})$
    e) $O(b^d)$

$$UCB1(n) = \frac{U(n)}{N(n)} + C \times \sqrt{\frac{\ln N(\text{PARENT}(n))}{N(n)}}$$

II.   [6 points] Game Playing II

In the real-world it is Black's turn. Suppose Black wants to apply MCTS. The root node shows the win stats for White, then every level in the tree alternates between win stats for Black and White. **Only 3 possible actions from any state. For tie-breaking, select left-most child first.**

Black   7/18

A   4/9   B   2/5   C   1/4

White

Black   1/5   0/0   3/4   0/2   D 1/1   1/2   0/0   0/0   0/0

What is the UCB1 value for the following nodes (use $C = 1$): **Round final answer to 3 digits.**

$UCB1(A) =$ **1.011** $UCB1(B) =$ **1.160** $UCB1(D) =$ **2.27**

III.   [5 points] KB I

Which of the following are both sound *and* complete?

    a) Truth table entailment in PL (**T**/F)
    b) Forward chaining with horn clauses in PL (**T**/F)
    c) PL resolution with CNF (**T**/F)
    d) PL inference with only modus ponens (T/**F**)
    e) FOL model checking (T/**F**)

IV.   [5 points] KB II

Recall the truth tables for the basic propositional logic formulas:

P	Q	$P \wedge Q$	$P \vee Q$	$P \Rightarrow Q$	$P \Leftrightarrow Q$
F	F	F	F	T	T
F	T	F	T	T	F
T	F	F	T	F	F
T	T	T	T	T	T

Suppose that **KB** = ¬(**P** ∧ **Q**) and **α** = ¬**Q**
KB ⊭ α (**T**/F)

Suppose that **KB** = ¬(**P** ⇔ **Q**) and **α** = (**P** ∧ ¬**Q**) ∨ (¬**P** ∧ **Q**)
KB ⊨ α (**T**/F)

V.   [5 points] KB III

Consider the following KB.

$C \wedge D \Rightarrow Y$

$R \wedge K \Rightarrow C$

$D \wedge Z \Rightarrow Q$

$D \Rightarrow R$

$B \Rightarrow D$

B

K

For this KB, which technique is most efficient to determine entailment?

a) Model Checking

b) Direct Proof Search

c) Resolution Based

d) Forward Checking

Is the following query entailed by the KB?

$KB \nvDash Z$ (**T**/F)