1. Perform minimax search with alpha-beta pruning for the following tree. Indicate which nodes are never visited and which branches are pruned (assuming that nodes are considered from left to right). Write the $\alpha$ or $\beta$ value next to each node. The utilities are indicated below the terminal nodes. Assume that Max goes first.

![Tree Diagram]

2. Consider the following fully observable two-player game. There are three cards facing up, with values 1, 2, and 3. MAX chooses a card. MIN flips a coin. If the result is heads, MIN chooses a card (from the remaining cards) and swaps cards with MAX. If the result is tails, MIN just chooses a card (again from the remaining cards). If MAX ends up with a higher card, then MAX wins; otherwise MIN wins. Assume the coin is biased, so it comes up heads 60% of the time.

Draw the search tree to model this game to decide which card MAX should choose.

3. Classify the environments of each of the following problems as (1) Fully or Partially Observable (2) Deterministic or Stochastic (3) Static or Dynamic and (4) Benign or Adversarial.
   a. Riding a bike
   b. Web-search engine performing a search
   c. Robotic Vacuuming
4. Consider the search tree in Figure 1. Each node represents a point on the Euclidean plane.
   The **Goal State** is (4, 4).
   The **Cost** from one state to another is the Euclidean distance between the two points.
   We first consider the **Uninformed** Search Algorithms: DFS, BFS, and UCS (uniform cost search). Assume that to break ties nodes are searched from left to right.
   a. Which uninformed search algorithm(s) find an **optimal** solution? What is the cost of the solution? Which nodes are expanded?
   b. Which uninformed search algorithm(s) find a **shortest** solution? What is the length of the solution? Which nodes are expanded?
   c. Which uninformed search algorithm expands the fewest nodes? Which nodes are expanded?

Now consider the **Informed** search algorithms Greedy-Best-First and A* with the Euclidean distance as a heuristic.
   d. Is the Euclidean distance an admissible heuristic? Explain.
   e. Which informed search algorithm finds an optimal solution? Which nodes are expanded?
   f. Which informed search algorithm finds a shortest solution? Which nodes are expanded?
   g. Which informed search algorithm expands the fewest nodes? Which nodes are expanded?

![Figure 1](image)

5. The CS Department needs to schedule \(x\) courses for next semester among \(y\) time slots and \(z\) rooms. Certain courses require the use of the computer lab and therefore cannot be scheduled at the same time. CS majors should be able to enroll in multiple classes, so any two courses that can be simultaneously taken by a CS major should not be scheduled at the same. Model this problem as a Constraint Satisfaction Problem. Describe the variables, domains, and constraints.
6. Consider the following CSP.

Variables: $W, X, Y, Z$

Domains:
- $D_W = \{1, 2\}$
- $D_X = \{1, 2, 3\}$
- $D_Y = \{1, 3\}$
- $D_Z = \{1, 2\}$

Constraints: $W \neq X, W \neq Y, W \neq Z, X \neq Z$.

Show the search tree that yields from applying backtracking with forward-checking and find a consistent assignment. Assume that variables are assigned alphabetically (so $W$ first, then $X$…) and values are assigned in increasing order (so 1, then 2…).

7. Consider the problem of assigning colors to the five squares on board below such that horizontally adjacent and vertically adjacent squares do not have the same color (so 2 and 4 may be assigned the same color). Assume there are two possible colors: red (R) and black (B). Formulated as a constraint satisfaction problem, there are five variables (the squares) and two possible values (R, B) for each variable.

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1 2 3
4 5
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a. Suppose we assign variable 1 to have value R, what is the result of the Forward Checking?

b. If initially every variable has both possible values and we run the Arc Consistency algorithm, what are the resulting domains for each of the variables?

c. If initially every variable has both possible values except variable 5 has only value B, what is the result of the Arc Consistency algorithm?