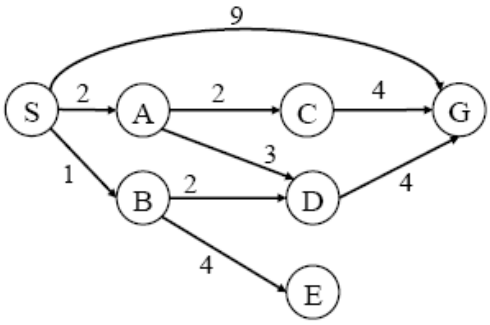
**1. Search**

Consider the following search problem. The start state is S and the only goal state is G. Note that the following problems variously reference both tree search and graph search. For questions which require a heuristic, use the one given below.




Heuristic

| S | A | B | C | D | E | G |
|---|---|---|---|---|---|---|
| 6 | 0 | 6 | 4 | 1 | 10 | 0 |

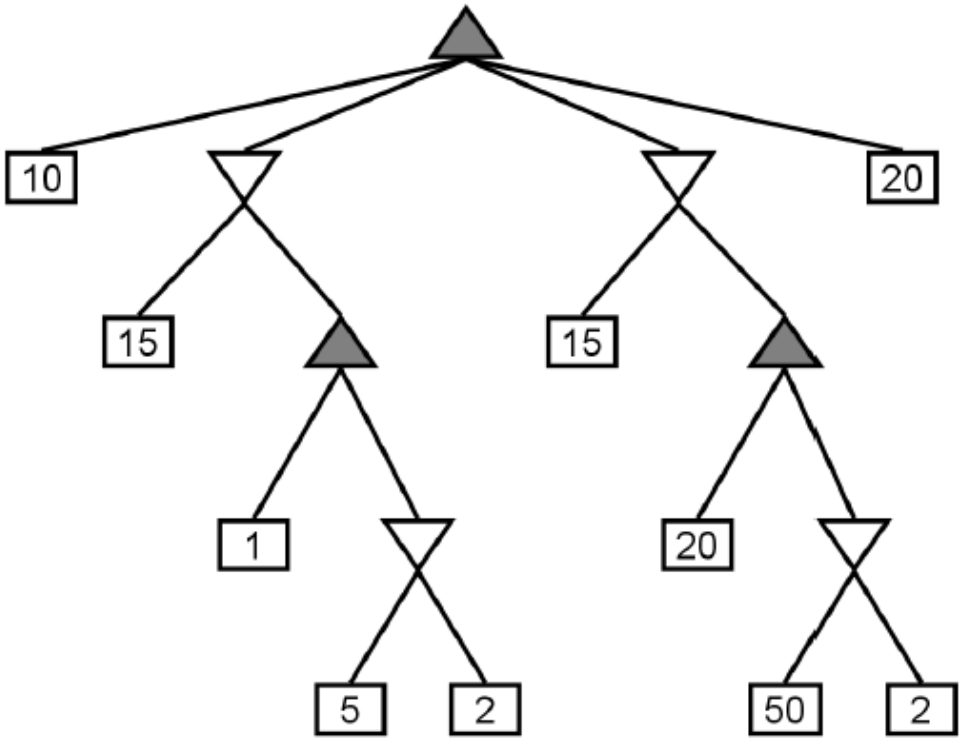
(a) What path will BFS return?
(b) What path will UCS return? List the order of nodes in the priority queue at each iteration of UCS.
(c) What path will greedy best first search return? List the order of nodes in the priority queue at each iteration of greedy best first search.
(d) What path will A* search return? List ? List the order of nodes in the priority queue at each iteration of A*.

Prove the following statements:

Breadth first search is a special case of best first search;

Uniform cost search is a special case of A* search.

**2. Game Tree Search**




Consider the game search tree above. In the nodes are game tree values of terminals.

1. What is the minimax value for the root?
2. Draw an X through any nodes which will not be visited by alpha-beta pruning, assuming children are visited in left-to-right order.
3. Is there another ordering for the children of the root for which more pruning would result? If so, state the order.

## 4. CSPs

Suppose we have the following CSP problem:

i. Variables: {X, Y, Z}
ii. Domains: Dom(X)={1,2,3}; Dom(Y)={1,2,3}; Dom(Z)={1,2,3}
iii. Constraints: C1: ALL-DIFF(X,Y,Z); C2: X+Y=5; C3: Y-Z=2.

Draw a search tree that solves this CSP using forward checking with the MRV, degree and least constraining value heuristics.

## 5. Knowledge Representation

1. What is the most general unifier for
   a) f(X,h(Y),h(a)) and f(h(h(Y)),h(b),Z)
   b) f(h(g(Z),Y),g(X,h(Y))) and f(X,Z)

2. Formulate the following English sentences into a knowledge base in first-order logic, and prove that "There is a member of the Alpine Club who is a mountain climber but not a skier" is not entailed by the knowledge base.
   a) Tony, Mike and John are members of the Alpine Club;
   b) Each member of the Alpine Club is either a skier or a mountain climber (or both);
   c) Mountain climbers do not like rain, and anyone who does not like snow is not a skier;
   d) Mike likes whatever Tony dislikes;
   e) Tony likes rain and snow.

3. Determine whether the following sentence is valid using resolution

$$\exists x \forall y \forall z \;\; ((P(y) \rightarrow Q(z)) \rightarrow (P(x) \rightarrow Q(x))$$