CS4725/CS6705
Sample Midterm

Name: SAMPLE SOLUTIONS

Student ID: _____

- The midterm is out of 30 marks.
- You will have 50 minutes to write the midterm. Manage your time wisely. If you are unsure about a question, move on to the rest of the midterm and come back to any problematic questions later.

1.	/ 5
2.	/ 6
3.	/ 5
4.	/ 6
5.	/ 8
Total	/ 30

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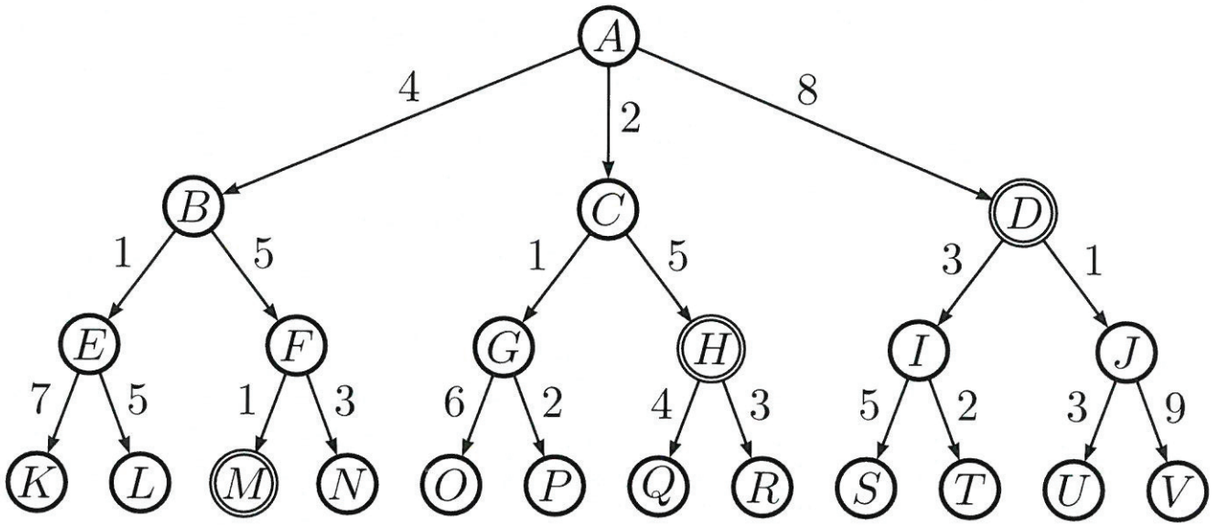
1. **(5 marks)** Suppose you are planning to perform a tree search (not keeping track of previously seen states in order to avoid expanding repeated states) in a search space that has the following properties:

   - The branching factor, b, is 5.
   - The cost of each action is 1.
   - All actions are reversible. If you can move from state A to state B, then you can also move from state B to state A.
   - There is at least one solution to the problem, and there could be multiple solutions. We know that each solution will occur at depth 7, at depth 8 or at depth 9, but we do not know how many solutions (if any) will occur at each of those depths.

   For each of the following uninformed search strategies, indicate whether or not the strategy is guaranteed to be **complete** and whether or not it is guaranteed to be **optimal**. (Just answer **Yes** or **No** in each box.)

	Complete	Optimal
Breadth-first search	Yes	Yes
Depth-first search	No	No
Depth-limited search, $l = 7$	No	Yes - if a solution is found – but a case could be made for the answer to be 'no'
Depth-limited search, $l = 9$	Yes	Yes
Iterative deepening	Yes	Yes

2. **(6 marks)** Consider the state space shown below. A is the start state, while D, H and M are all goal nodes. Arrows represent possible actions, and the numbers on the arrows represent action costs. Note that the arrows are directed; for example, $A \rightarrow B$ is a possible action, but $B \rightarrow A$ is not.



For each of the following search algorithms, write down the order in which nodes would be selected to be expanded during the search, as well as the solution path that would be returned and its cost.

Assume that the algorithms are implemented so that *ties are broken alphabetically.*

(a) **Depth-First Search**
Order of expansion of nodes: A B E K L F M

Solution path returned and total path cost: A → B → F → M (cost: 10)

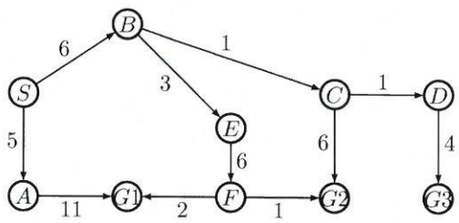
(b) **Breadth-First Search**
Order of expansion of nodes: A

Solution path returned and total path cost: A → D (cost: 8)

(c) **Uniform-Cost Search**
Order of expansion of nodes: A C G B E P H

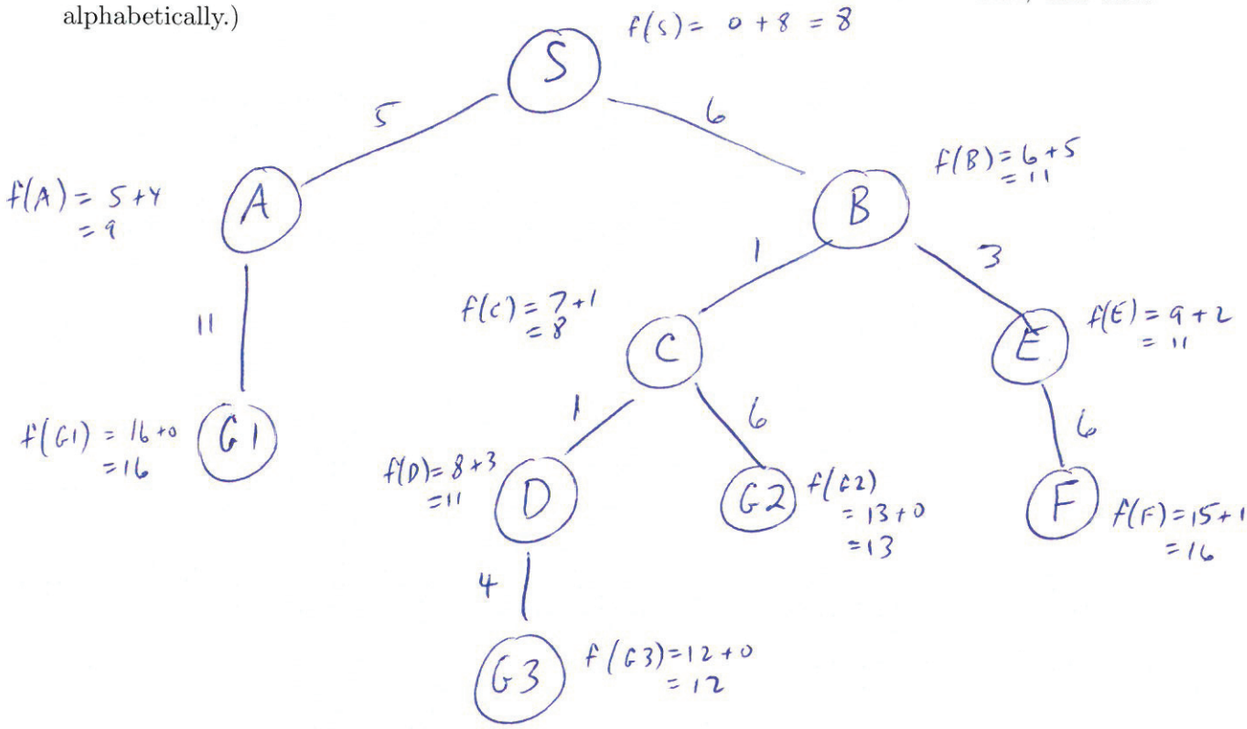
Solution path returned and total path cost:
A → C → H (cost: 7)

3. **(5 marks)** Consider the problem of getting from node S to a goal node ($G1$, $G2$ or $G3$) in the graph below.



Trace the operation of **A* search** with a heuristic function that has values $h(S) = 8$, $h(A) = 4$, $h(B) = 5$, $h(C) = 1$, $h(D) = 3$, $h(E) = 2$, $h(F) = 1$, $h(G1) = 0$, $h(G2) = 0$, $h(G3) = 0$.

Draw the search tree that would be built; beside each node in the search tree, show the calculation of its f-value. Also, fill in the table below. (If two nodes on the frontier have the same f-value, then break ties in favour of the node with the lower h-value, and then alphabetically.)



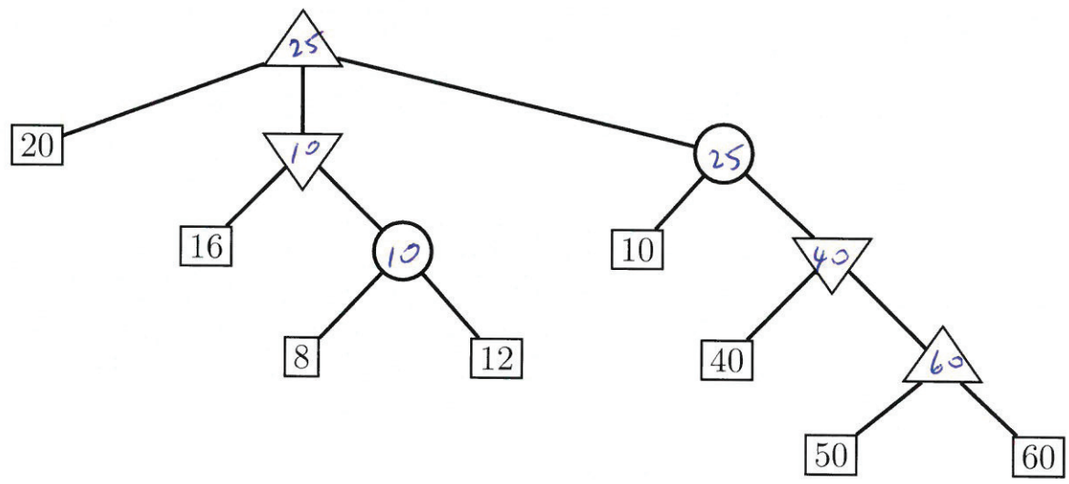
Node selected for expansion	Priority queue (show nodes and their f-values)
S	A^{9} B^{11}
A	B^{11} G1^{16}
B	C^{8} E^{11} G1^{16}
C	E^{11} D^{11} G2^{13} G1^{16}
E	D^{11} G2^{13} G1^{16} F^{16}
D	G3^{12} G2^{13} G1^{16} F^{16}
G3	Goal found!

Solution path found: S → B → C → D → G3

Cost of solution path: 12

4. **(6 marks)** Consider the game tree below, which contains MAX nodes, MIN nodes and chance nodes. For the chance nodes, the probability of each outcome is equally likely.

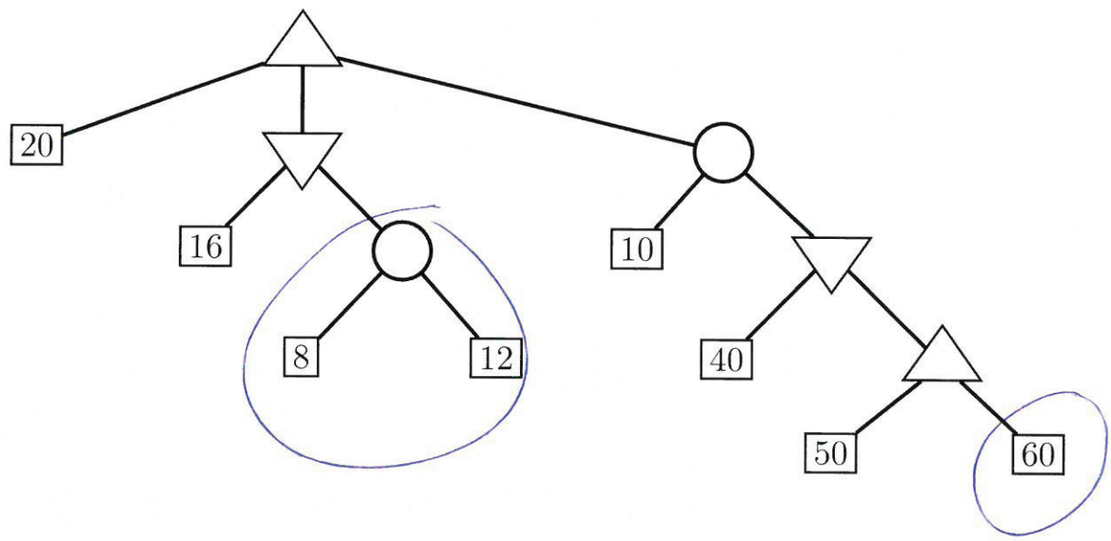
   (a) Fill in the expectiminimax value of each node, assuming that you visit every node while solving this tree.



   (b) Based on our discussion of pruning (in class and on Assignment 3), is it possible to prune any branches in the tree?

   ____ No: Provide a brief justification.

   ✓ ____ Yes: Circle all nodes or subtrees below that do not have to be visited.



5. **Short-answer questions (8 marks)**

(a) (3 marks) In an adversarial search, suppose that you are using the minimax algorithm with α-β pruning. You can assume that you are applying this to a game tree for which you have time to explore all the way down to the leaf nodes.

Which of the following statements is/are true about α-β pruning? Circle **all** that apply.

i. It can reduce computation time by ignoring portions of the game tree.
ii. It is generally faster than minimax, but loses the guarantee of finding an optimal move.
iii. For every node that is visited, it returns the same minimax value as would be returned by the minimax algorithm without α-β pruning.

(b) (3 marks) Suppose that you are solving a search problem for which $h_1(s)$, $h_2(s)$ and $h_3(s)$ are all admissible heuristics. Which of the following are also guaranteed to be admissible? Circle all that apply.

i. $h_4(s) = h_1(s) + h_2(s) + h_3(s)$
ii. $h_5(s) = \frac{h_1(s)}{6} + \frac{h_2(s)}{3} + \frac{h_3(s)}{2}$
iii. $h_6(s) = min(h_1(s), h_2(s), h_3(s))$
iv. $h_7(s) = max(h_1(s), h_2(s), h_3(s))$
v. $h_8(s) = min(h_1(s),\ h_2(s) + h_3(s))$
vi. $h_9(s) = max(h_1(s),\ h_2(s) + h_3(s))$

(c) (2 marks) Consider a tree search in which the maximum depth of any node is m. Also, let $depth(n)$ represent the depth of any node n.

If we were to perform a best-first search with $f(n) = m - depth(n)$, then this search would behave exactly like which of the following search techniques?

i. depth-first search
ii. breadth-first search
iii. iterative deepening search
iv. uniform cost search, with a cost of 1 for each action