For each question on Quiz #1, “Zero” gives the percentage of students who received zero, “Partial” gives the percentage who received partial credit, and “Perfect” gives the percentage who received 100%. (Due to rounding, numbers shown below are only an approximate estimate.)

Problem 1
Zero: ~5% (~4 students), Partial: ~58% (~48 students), Perfect: ~37% (~30 students)

Problem 2
Zero: ~6% (~5 students), Partial: ~7% (~6 students), Perfect: ~87% (~71 students)

Problem 3
Zero: ~3% (~2 students), Partial: ~96% (~79 students), Perfect: ~1% (~1 student)
1. (24 pts total, 1 pt each) Search Properties. Fill in the values of the four evaluation criteria for each search strategy shown. Assume a finite branching factor; $d$ is the depth to the shallowest goal node; $l$ is the depth limit to some positive $\varepsilon$; in bidirectional search both directions use breadth-first search. 

Note: These assumptions are the same as in Figure 3.21 of your textbook.

<table>
<thead>
<tr>
<th>Search Strategy</th>
<th>Complete?</th>
<th>Time Complexity</th>
<th>Space Complexity</th>
<th>Optimal?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth-First</td>
<td>No</td>
<td>$O(b^m)$</td>
<td>$O(bm)$</td>
<td>No</td>
</tr>
<tr>
<td>Breadth-First</td>
<td>Yes</td>
<td>$O(b^d)$</td>
<td>$O(b^d)$</td>
<td>Yes</td>
</tr>
<tr>
<td>Uniform-Cost</td>
<td>Yes</td>
<td>$O(b^{1+\text{floor}(C*/\varepsilon)})$</td>
<td>$O(b^{1+\text{floor}(C*/\varepsilon)})$</td>
<td>Yes</td>
</tr>
<tr>
<td>Depth-Limited</td>
<td>No</td>
<td>$O(b^l)$</td>
<td>$O(bl)$</td>
<td>No</td>
</tr>
<tr>
<td>Iterative Deepening</td>
<td>Yes</td>
<td>$O(b^d)$</td>
<td>$O(bd)$</td>
<td>Yes</td>
</tr>
<tr>
<td>Bidirectional (if applicable)</td>
<td>Yes</td>
<td>$O(b^{d/2})$</td>
<td>$O(b^{d/2})$</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Your answer will be considered correct if it differs from that shown below by no more than ±1, e.g., $O(b^d)$ vs. $O(b^{d+1})$.

2. (16 pts total, 4 pts each) Task Environment. Your book defines a task environment as a set of four things, with acronym PEAS.

Fill in the blanks with the names of the PEAS components.

Performance (measure)      Environment      Actuators      Sensors
3. (60 pts total, 10 pts each) Execute Tree Search through this graph (i.e., do not remember visited nodes). The values are the step costs next to each arc. The children of each node are indicated by the arrows out of that node. The children of a node are returned in top-to-bottom order.

Specifically, the children of S are (A, B) and the children of A are (A, D), in that order.

For each search strategy below, show the order in which nodes are expanded (i.e., to expand a node means that its children are generated), ending with the goal node that is found. Show the path from start to goal, or write “None”. Give the cost of the path found, if any. The first one is done for you, as an example.

3.a. DEPTH FIRST SEARCH.
Order of node expansion: S A A A A ...
Path found: None Cost of path found: None

3.b. (10 pts) BREADTH FIRST SEARCH.
Order of node expansion: S A B A D G
Path found: S A D G Cost of path found: 37

3.b. (10 pts) UNIFORM COST SEARCH.
Order of node expansion: S A B C D G
Path found: S B C D G Cost of path found: 23

3.c. (10 pts) GREEDY (BEST-FIRST) SEARCH.
Order of node expansion: S A A A A ...
Path found: None Cost of path found: None

3.d. (10 pts) ITERATED DEEPENING SEARCH.
Order of node expansion: S S A B S A A D G
Path found: S A D G Cost of path found: 37

3.e. (10 pts) A* SEARCH.
Order of node expansion: S A B C D G
Path found: S B C D G Cost of path found: 23

3.f. (10 pts total, 5 pts each) Is the heuristic admissible at nodes B & C? (Yes or No) Yes

Is the heuristic consistent at nodes B & C? No

h(B) = 10 < h*(B) = 14
h(C) = 7 < h*(C) = 13
h(B) = 10 > c(B,C) + h(C) = 1 + 7 = 8

Minor errors will receive partial credit. The TA will determine how much credit to allow in any particular case.

It is OK if you wrote SAAAA... instead of SAAAA... It is OK if you said None for “Path found.” It is OK if you said N/A for “Cost of path found,” or left it blank.

Please see the lecture slides for Uninformed Search, topic “When to do Goal-Test? When generated? When popped?” for clarification about exactly what to do in practical cases.

Due to discrepancies with the previous tests supplied as study guides, for Quiz #1 only, S A B A D C A D G will receive full credit.

Due to discrepancies with the previous tests supplied as study guides, for Quiz #1 only, S S A B S A A D B C S A A A D D G will receive full credit.

BFS does the Goal-test before the child is pushed onto the queue. The goal is found when D is expanded.

UCS does the Goal-test when the node is popped off the queue.

IDS does the Goal-test before the child is pushed onto the queue. The goal is found when D is expanded.

A* does the Goal-test when the node is popped off the queue.