I&C SCI 46 Diagnostic Exam 3, Fall 2022

DO NOT OPEN EXAM UNTIL INSTRUCTED TO DO SO

SILENCE MOBILE PHONE AND OTHER DEVICES

This is a diagnostic exam intended to help you evaluate your readiness for the real exam.

Write the following information clearly. You may write this information only before the instructor calls to begin the exam. You may not write this information after the instructor calls to stop writing.

Name: ____________________________

UCI Email Address: ____________________________ @uci.edu

UCI Student ID #: ____________________________

Read and understand the following rules; failure to abide by these rules, or directions given by course staff during the exam, may result in disciplinary action, including but not limited to a failing grade in the class.

• This exam is solely for students enrolled in this lecture. Anyone not enrolled in this lecture may not take an exam.

• Keep your UCI ID readily accessible during the test. Proctors may request to see it.

• This exam is closed book, closed notes, and is individual effort. Once course staff begin passing out exams, you may not communicate with anyone other than proctors for any reason, nor may you have electronics, including calculators watches and phones, available to you during the test for any reason. YOU DO NOT NEED A CALCULATOR!

• If you leave your seat during the test for any reason, your instructor may collect it and deem you to have turned it in. Do not ask proctors for an exemption to this, they are not authorized to grant such.

• If you are still seated at X:35 AM at the real quiz, you may not leave your seat until explicitly dismissed by the instructor. Leaving after X:35 AM and before being dismissed may result in a penalty.

• You must take the exam in your assigned seat unless the professor (not a TA) tells you otherwise. You may not open the exam until explicitly told to do so by the professor. The instructor will call to cease writing at X:45 AM, at which point you must immediately cease writing and close the exam. You may not write any further at that point, including finishing one’s current sentence.

• If you believe a question is ambiguous, write at least two reasonable interpretations and indicate clearly which one you will be using. Then answer your question with that assumption. Unless your interpretation makes the problem much more trivial than intended, we will grade your response as if one of us had made that clarification.

• The purpose of the real exam is to evaluate how well you understand the material presented in the course. It is an academic integrity violation to do anything that subverts the goals of this assessment including, but not limited to, not doing your own work or submitting that of anyone else.

• Write your answers in the space provided for each question.

• Write your UCI email at the top of each answer page. You may not do this until the exam has begun. There is one point for doing this.

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Nothing you write on this page will be graded. The next page in this booklet contains a spot to answer these questions. You may use this page as scratch paper if you would like, and room to do so exists.

1. (a) (1 points) In the following graph, clearly fill in the edges that are in the single-source shortest path tree starting at \( s \), such as one that would be output by Dijkstra’s Algorithm. You do not need to show all of your work, but it is recommended that you keep your work reasonably well organized in the chart provided.

<table>
<thead>
<tr>
<th>( v )</th>
<th>intree(( v ))</th>
<th>parent(( v ))</th>
<th>dist(( v ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>( s )</td>
<td>N/A</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>( a )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( b )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( c )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( d )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( e )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( f )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( g )</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) (0.5 points) For the above graph, is the single-source shortest path tree rooted at \( s \) unique? Why or why not?

(c) (0.5 points) What is the shortest path from \( s \) to \( g \)?
1 (a) Fill in the edges for your answer:

(b) For the above graph, is the single-source shortest path tree rooted at $s$ unique? Why or why not?

(c) What is the shortest path from $s$ to $g$?
Nothing you write on this page will be graded. The next page in this booklet contains a spot to answer these questions. You may use this page as scratch paper if you would like, and room to do so exists.

2. (1.5 points)

(a) Here is a binary heap, drawn as a tree. What is the array/vector representation of the heap? Write only the eight integers in the form.

(b) What is the result of a remove-min operation on this heap? You may want to draw the resulting heap, and on the answer page, you will describe the result.

(c) What is the string/vector representation of the resulting heap?

3. (1 point) Find the minimum spanning tree of the following graph:
Question 2(a). Please write only the vector representation of the heap.

Question 2(b). Refer to each node by the character contained within it.

What is the root of the tree?

For each node, list the character contained in the left and right children nodes. For any `nullptr`, leave the relevant box blank.

<table>
<thead>
<tr>
<th>Node</th>
<th>Left Child</th>
<th>Right Child</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Question 2(c). Please write only the integers in the vector representation.

Write your answer for question 3 here.
4. (1 point) Give a valid topological ordering of the following graph. Write only the eight letters on the response page (no arrows, commas, etc).

```
  K
 /|
/  |
 T  Y
 /|
/  |
P  R
 /|
/  |
 Q W
```

5. (1.5 points) Let $G$ be a simple, undirected graph with positive integer edge weights. Suppose we want to find the maximum spanning tree of $G$. That is, of all spanning trees of $G$, we want the one with the highest total edge weight. If there are multiple, any one of them is fine to find.

Describe a simple algorithm to accomplish this.

6. (2 points) Suppose we are writing code for a priority queue, implemented as a min heap (using a `std::vector`). We have `insert`, `min` and `extract-min` written and we want to add a function `where-is-key(k)`. This function is designed to answer the following query: is $k$ in the heap, and if so, which index in the vector holds $k$? I want this to run in $O(\log n)$ time. The other operations' running times may increase by a factor of $O(\log n)$ if needed. Explain how to do this. You may use $O(n)$ additional space to support this operation.

You will still get full credit if your running time is in expectation $O(\log n)$ instead of guaranteed, and/or your $O(n)$ additional space is in expectation. However, to get this credit, if either or both is in expectation, you need to state that explicitly in your answer.
Question 4. Write only the relevant characters in this box.

Write your answer to question 5 here.

Write your answer to question 6 here.