CSIEB0100 Data Structures, Fall 2022
Final Exam (110 points)

ID: _____ Dept:_____ Name: _____

1. **(20 points)** Based on the problem type in parentheses (True/False, fill in the Blank (FIB), or briefly answer (ANS)), answer the following questions.

1-1 What is the maximum and minimum number of **leaf nodes** of a complete binary tree of height 5? Answer the same question for a complete binary tree of height *k*.

_____ (FIB)

1-2 Assume that a max heap with 20 nodes is represented sequentially using an array T as explained in class. Where is the largest number in T? What is the range of indexes where the smallest number may reside?

_____ (FIB)

1-3 On a binary search tree, what will happen if the root is deleted? Which node will become the new root?

_____

_____

_____ (ANS)

1-4 Given the inorder and preorder traversal results, we can always construct a unique binary tree. _____(True/False)

1-5 Consider a max heap *T* with 30 nodes represented by an array as discussed in class. How many swapping do we need if a value **smaller than** all existing values is inserted? Where will the new value be placed? Answer the same questions above when a value **larger than** all existing values is inserted.

_____

_____ (FIB)

1-6 Given an undirected graph *G* which has exactly two connected components *H1* and *H2*. What is the relationship between the set of vertices *V1* of *H1* and the set of vertices *V2* of *H2*? Let *V* be the set of vertices of G. What is the relationship between *V*, *V1* and *V2* ? Briefly explain you answers.

_____

_____

_____ (ANS)

1-7 Given a biconnected graph G, will the graph be connected after the removal of an edge? Will G be connected after the removal of a vertex? Consider all possible cases and briefly explain your answer.

_____

_____

_____ (ANS)

1-8 In the three minimum-cost spanning tree algorithms we discussed in class, which one keeps a single tree and expand it until the final tree is found? Which one select multiple edges at each pass? Are the spanning trees found by them exactly the same? What about the cost?

_____

_____

_____ (ANS)

1-9 The quicksort algorithm has the best average case complexity. Therefore, it is better to use it in all cases. _____(True/False)

2. **(20 points)** The NDHU campus is large with many buildings, facilities and roads. New students tend to get lost, especially in the first semester. It would be nice to have a customized APP to help the students. Outline the design by answering the following questions. (Don't need to write the complete code. Just the key elements of the C++ classes. You may use existing C++ classes in the textbook w/o copying in here. Specify your selection clearly.)
   (a) Choose an appropriate **data structure** for the problem and briefly explain it.
   (b) Outline the skeleton of a `NDHUCampus` class to maintain the information about all relevant entities: **buildings**, **facilities** and **roads**.
   (c) Write `Add/Delete` functions to add/delete entities on the campus.
   (d) Write a `Find` function to search for a particular entity.
   (e) Outline how would you test your classes/functions in the main program.

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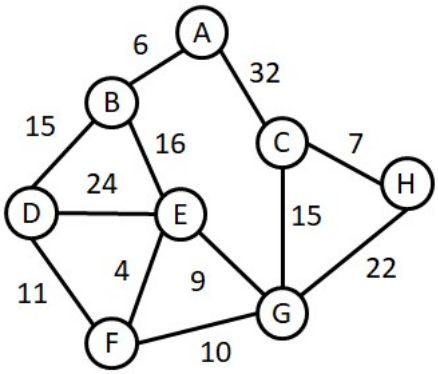
3. **(25 points)** Show the intermediate results of each pass of the following sorting algorithms on the initial list of numbers: 120, 205, 348, 6, 37, 295, 16, 41, 430.
   (a) Quick sort with median-of-three method to choose the pivot.
   (b) Recursive merge sort
   (c) Natural merge sort
   (d) Heap sort using max heap
   (e) Radix sort

(This page is left empty for you to answer the question.)

4. **(20 points)** Answer the following questions about binary search trees (BSTs).
   (a) Draw the final BST after inserting elements 60, 25, 15, 8, 35, 27, 82, 73, 50, 40, 77, 92, 88, 90 in that order.
   (b) Draw the tree after deleting 15 from the BST in (a).
   (c) Draw the tree after deleting 60 from the resulting tree of (b) using the largest element in the left subtree for replacement.
   (d) Draw the tree after deleting 82 from the resulting tree of (c) using the smallest element in the right subtree for replacement.
   (e) List the elements of pre-order, in-order, and post-order traversals of the resulting tree of (d).

5. **(25 points)** Answer the questions using the following graph.



(a) List the node sequences of DFS and BFS starting from F. (Follow the order of the node label whenever a choice is needed.)

(b) Draw the sequence of edges (represented by edge weight) added to the minimal-cost spanning tree by the Kruskal's algorithm.

(c) Do the same thing as (b) using Prim's algorithm.

(d) Do the same thing as (b) using Sollin's algorithm.

(e) Find the shortest paths from F to all other vertices using Dijkstra's algorithm.

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