Name and Username (abc123): _____

- You have 1 hour and 50 minutes to complete this exam.
- It contains **11** problems over 4 pages.
- The exam has a total of 160 points.
- Select questions totaling 100 points to complete.
- If you submit more than 100 point worth of questions, the **lowest** scoring questions will be counted towards your grade.
- If a question has multiple parts, you must answer them all.
- Submit each question to it's area in BBLearn.
- This exam is limited **open book**. You may use:
  - Zybooks
  - Any material posted in BBLearn (lectures, homeworks, etc)
  - Any material you created (Homework answers, notes, etc)
  - The website `https://www.wolframalpha.com` for calculations
  - The Python 3 Docs `https://docs.python.org/3/index.html`
  - A calculator (physical or software)
  - Python 3
  - Any IDE or text editor of your choosing.
- You may use scrap paper.
- You may not talk to/message anyone during the exam. All work must be your own.
- You may not search websites not listed above.
- If you are unsure of a instruction, write how you interpreted it before your answer.
- **Good Luck!**

1 Short Answer Questions

These questions are essays. They should be answered in plain text. You might have to make tables or write equations in plain text.

Question 1 : 10 points

Create a min-heap by inserting the following numbers into an empty min-heap in the order listed.

[0, 13, 16, 17, 6, 3, 9, 8, 1, 15]

Fill in the preorder (5pts) and postorder (5pts) traversals of the tree you created.

Each number is worth 0.5 points.

Question 2 : 10 points

Create a Huffman Code using the following probabilities.

a	23%
b	15%
c	22%
d	16%
e	24%

When merging trees, always put the lowest probability on the left.

(a) (2 points) What is the Binary Code Generated for a?

(b) (2 points) What is the Binary Code Generated for b?

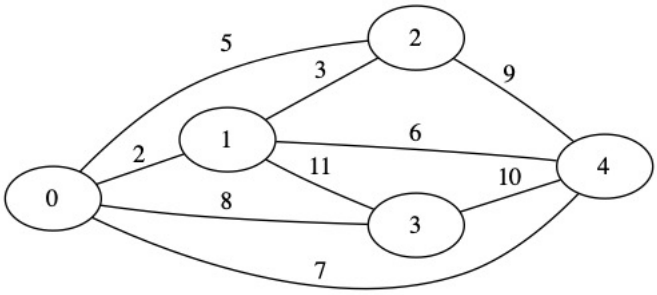
(c) (2 points) What is the Binary Code Generated for c?

(d) (2 points) What is the Binary Code Generated for d?

(e) (2 points) What is the Binary Code Generated for e?

Question 3 : 10 points

Run Prim's Algorithm on the below graph.



Start Prim's Algorithm at node 2.

List each edge in the order it is added to the graph.

Fill out the below questions based on how Prim's algorithm runs.

(a) (2 points) The first edge added is (?, ?) with weight ?

(b) (2 points) The second edge added is (?, ?) with weight ?

(c) (2 points) The third edge added is (?, ?) with weight ?

(d) (2 points) The fourth edge added is (?, ?) with weight ?

(e) (2 points) What is the total weight of the MST?

Question 4 : 10 points

Use the **Master Theorem** to determine the Θ bound for each of the following.

(a) (2 points) $T(n) = 4T(n/2) + n^3$

(b) (2 points) $T(n) = 27T(n/3) + n$

(c) (2 points) $T(n) = 8T(n/2) + 1$

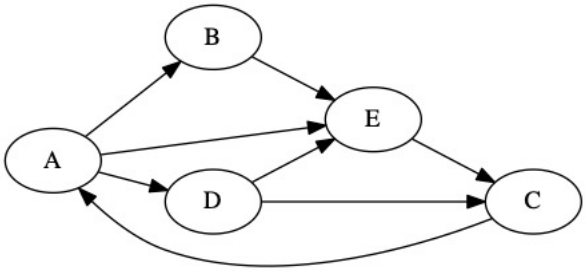
(d) (2 points) $T(n) = 25T(n/5) + n^2$

(e) (2 points) $T(n) = 2T(n/2) + n\log_2(n)$

Question 5 : 10 points

Run a **Depth First Search** on the following graph. Fill out the start and end time for each node.

Start at **Node A**. Break ties using alphabetical order.



(a) (2 points) What is the start and end counter for node A?

(b) (2 points) What is the start and end counter for node B?

(c) (2 points) What is the start and end counter for node C?

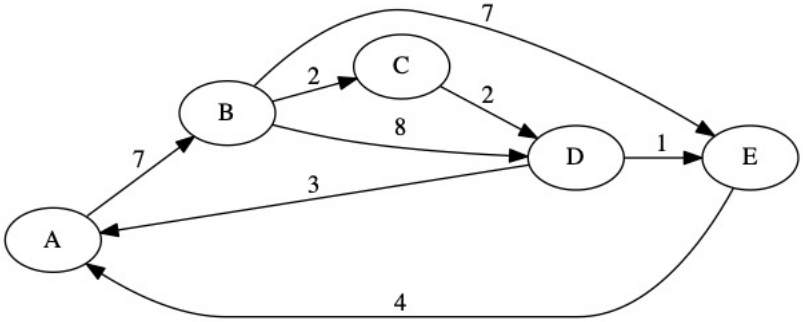
(d) (2 points) What is the start and end counter for node D?

(e) (2 points) What is the start and end counter for node E?

Question 6 : 10 points

Run **Dijkstra's Algorithm** on the following graph. Write the Distance Array after each iteration.

Start at **Node A**.



(a) (2 points) What is the initial Distance Array?

(b) (2 points) What is the Distance Array after 1 iteration?

(c) (2 points) What is the Distance Array after 2 iteration?

(d) (2 points) What is the Distance Array after 3 iteration?

(e) (2 points) What is the Distance Array after 4 iteration?

2 Algorithm Design Questions

Describe your algorithm using a combination of psuedocode and text description. Make sure to be specific about data structures and algorithms you are using.

Question 7 : 20 points

You have a collection of k sorted linked lists. You need to merge them into a single new sorted list. There are a grand total of n numbers in all input lists combined. The numbers may not be distributed evenly across all the lists. Propose an algorithm to merge the k sorted lists in $O(n \log_2 k)$ runtime. (Hint: A heap will help.)

Question 8 : 20 points

You have a binary search tree T. You want to print the nodes in **preorder**. Propose an algorithm to give the preorder printout **without** using recursion. Your solutions must be **iterative**. (Hint: A stack will help.)

Question 9 : 20 points

Morse Code is a method for sending messages using only dots and dashes. Messages can be sent electronically or using physical means, such as banging on a pipe. A **dot** is a short noise. A **dash** is a long noise. Only the upper case letters and digits are handled by Morse Code. This allows for an easy and consistent way to send messages.

Imagine you wanted to create your own version of Morse Code. Come up with an algorithm for assigning sequences of dots and dashes to specific letters.

Question 10 : 20 points

Imagine there has been a disease outbreak at a hospital. The hospital has records of which patients potentially had contact with each other and when. They also know which patients eventually came down with the disease.

Propose an algorithm to determine who the most likely **patient zero** was. The **patient zero** is the person who is suspected to be the first person to have the disease and transmit it others.

Question 11 : 20 points

Imagine a hurricane has hit your city. Electrical wires are down throughout the city. The electrical company has a preexisting map of all the original electrical wires. They have also sent teams out and have a list of all downed wires. Many areas have redundant wires for exactly this type of emergancy. Not all wires need to be repaired for all customers to have electricity.

Propose an algorithm to determine which wires to repair in what order.