Montana State University Computer Science Department

Graduating Senior Exam

Spring Semester 2022, 80 minutes.

Your performance helps us assess how well we are meeting our stated learning outcomes for computer science majors. To pass this exam, spend at least 45 minutes in order to provide a carefully reasoned answer to each question. This information will help us make improvements.

Name Ben Holmgren

Question 1: A company uses a ticket system for customer service. Each ticket is given an urgency score when it is entered into the system. For example, a VIP customer would receive a higher urgency score than a regular customer. Assume that the urgency scores range from 1 to 10,000. The company's customer service team needs a way to find the most urgent ticket in the system and remove it when it has been addressed. New tickets can arrive at any time.

a) What simple data structure would best model this situation? Explain.

An array, which is sorted by urgency score.
Query time for next customer would be O(1) and update time is O(log n)

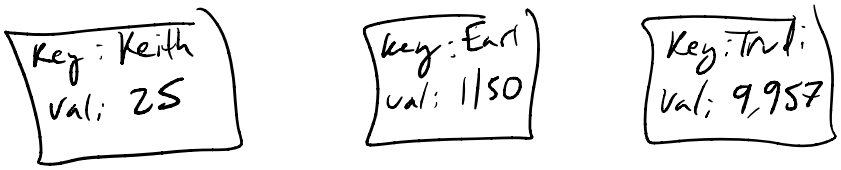
b) Describe one way in which this data structure could be implemented and draw a picture of that data structure.

Store in each entry of the list the customer's name & urgency score, and keep sorted correspondingly to urgency. Most urgent is 1st in the list, updates are done by binary search in O(log n) time.



c) Describe a second way in which this data structure could be implemented and draw a picture of that data structure.

You could also maintain a dictionary, with keys being a person's name and values being urgency scores.



Question 2: Write a function in a language of your choice that has two parameters: a string and a character. The function should return the number of times that the character occurs in the string.

Your language of choice (e.g. Python): Python

Your solution:

```
# num_chars returns # occurences of a character
# 'c' in a string 's'

def num_chars(s, c)

    count = 0

    for i in range(len(s)):

        if s[i] == c:

            count += 1

    return count
```

Question 3: Consider a singly linked list that contains **n** floating point numbers and is maintained in ascending order. An additional **k** floating point numbers will be added to the list, one at a time. You may assume that **k << n**.

Best case time complexity of algorithm:

$\Omega(k)$

Explanation of best case time complexity:

It could work out that all k additional numbers are added in ascending order, and come perfectly in order before the beginning of the sorted list. In this case, the list is operated in only k operations.

Worst case time complexity of algorithm:

$O(k \cdot n)$

Explanation of worst case time complexity:

In the worst case, it could be possible that all k values are added in descending order, and each new addition fits in the ordering at the end of the singly linked list. In this case, n operations must be done per new value to fit in all k new values & maintain the ordering.

Question 4: List any extracurricular community involvement (e.g. the Gallatin Valley Food Bank or coaching), extracurricular university involvement (e.g. Engineering Ambassadors, Swing Cats, AWC or ACM) or paid internships (e.g. Workiva intern or Undergraduate Course Assistant) that you were involved with during your time at MSU. For each activity, (1) **provide** the name of the organization, (2) **describe** briefly your main activities and (3) **estimate** the total number of hours you spent.

Organization	*Main Activities*	*Hours Spent (estimate)*
MSU CS & math dept	Undergrad research	15 / week, 8 semesters
MSU CS Dept	TA	10 / week, 1 semester
Brightvine	Intern, blockchain	15 / week, 1 semester
CompTa G Club	seminars, club president	5 / week 8 semesters
Montana Democrats	Volunteer organizer	5 / week, 1 semester
Math Club	math competitions	2 / week, 2 semesters

Question 5: IEEE P7003 defines the Algorithmic Bias Standard.

a) Describe briefly what algorithmic bias is.

The possibility of an algorithm, implemented by a human, to have inputs which are not anticipated by the algorithms author due to the author's background.

b) Provide a hypothetical example of how algorithmic bias could manifest itself in college admissions software.

Algorithms could, perhaps, be used to automate the job of predicting how much a person is likely to be able to spend on tuition at a given college.

Such an algorithm may be based on the assumption that a person with high family earnings and from an affluent neighborhood may be able to pay full tuition, which could not necessarily be the case, due to family conflicts etc.

Question 6: In 2010 Oracle sued Google claiming copyright and patent infringement for 11,500 lines of Java API copied code. Google used this small subset of code from the JAVA API for their mobile platform operating system. Pick a side (Google or Oracle) to win this lawsuit and explain 3 possible impacts to the computing industry of this win.

Side you choose to win: GOOGLE

First possible impact: The assumed stringency on copying code in the eyes of the law becomes less strict. It's easier to copy code, so more people do it.

Second possible impact: Google's mobile operating system is built rapidly (they had a head start) but gets bogged down by Java's slow codebase & in the end has few performance advantages, aside from speed to market.

Third possible impact: Oracle becomes no longer viable, because all of its code is technically now Google's anyway. Oracle goes out of business, Google is a Mega-monopoly, and kids learn Go instead of Java.

Question 7: In the ACM Code of Ethics and Professional Conduct, one ethical principle stated is to ***avoid harm***. Describe three different types of harm that the software of an autonomous, self-driving car might cause.

First type of harm: Harm to passengers outside of the car (That car could crash!)

Second type of harm: Harm to pedestrians in the way of the car (that car could hit them!)

Third type of harm: Harm to all property within a 50 foot distance to a road. (Car could drive off the road & hit mailboxes, fences, houses, you name it!)

Question 8: Describe your one-year plan following graduation. If you plan to work, list where you have applied (the company and the position) and mention whether you have received any offers. If you plan to go to graduate school, list where you have applied (the school and the area of study) and mention whether you have received any acceptances.

I've been offered a job as a blockchain engineer at Brightvine, a Bozeman-based startup. I'll either work there for a year and apply for PhD programs, or conduct research in combinatorics in Budapest, Hungary, through a Fulbright scholarship I've applied for, if I'm selected. For grad school, I plan to apply to: Oxford, Alfred Renyi institute, UC Irvine, U of Utah, UC Berkeley, Stanford, U of Washington, UBC, and Illinois.

Question 9: List any organized social activities that you were involved with during your time at MSU. For each activity, (1) **provide** the name of the organization, (2) **estimate** the total number of hours you spent.

Organization Name	*Hours Spent (estimate)*
Wind drinkers volunteer/racing	40

Question 10: List any activities that you were involved with during your time at MSU that prepared you to work more effectively with teammates whose backgrounds are significantly different than your own. For each activity, (1) **describe** the activity and (2) **estimate** the total number of hours you spent.

Activity Description	*Hours Spent (estimate)*
Rock / Ice Climbing	10 / week 8 semesters
Brown Maker, La Parilla	10 / week 2 semesters

Question 11: Name the most sophisticated version control system that you use and describe three nontrivial features it has**.**

Name of most sophisticated version control system:

Git / Github

Non-trivial feature 1: Merge conflicts, which identify when simultaneous contributions conflict w/ each other

Non-trivial feature 2: Pull requests, which allow changes to be made to permissioned code

Non-trivial feature 3: Forking, which creates an autonomous copy of the current repository to create a different version of the software separately from the original.

Question 12: During your time at MSU, list any major non-classroom, non-paid activities that you engaged in to help prepare for your computer science career. For example, you might have taught yourself a programming language or attended a workshop on a CS topic. For each activity, **estimate** the number of hours spent**.**

Activity Description	*Hours Spent (estimate)*
Book clubs in linear algebra	50
Book club in quantum computing	70
Self-taught algebraic geometry	40
self-taught category theory	30
Git workshop	5
Canadian conference on Comp. Geom.	15
Symposium on Comp. Geom.	15

Best wishes wrapping up the semester and in the future!

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