

University of Waterloo
CS240 Winter 2023
Assignment 4 Post Mortem

Question 1 (Hashing Examples) [3+3+3+3+1+1=14 Marks]

- For part (a), some students inserted new elements to the end of the linked list instead of the beginning.
- For part (e), a common incorrect answer was that the secondary hash function was dependent on the first. In this case, the answer is incorrect since we are performing the mod operation by a different digit, thus there won't be any dependencies on a randomized input.
- For part (f), a frequently appearing incorrect answer was that the chosen hash function would lead to infinite loops. In general with Cuckoo Hashing, if an insertion seems to be approaching an infinite loop (such as when we exceed $2n$ iterations), we simply rehash.

Question 2 (Chaining) [1+2+1+3+4=11 Marks]

- For part (a), the most frequent incorrect answer was $\frac{1}{M}$, most probably as the result of not reading the question fully.
- For part (b), a common wrong answer was $\frac{1}{M^n}$. Some answers which had lost marks also failed to provide sufficient justification.
- For part (c), most answers lost marks due to an insufficient explanation of why the probability is 1.
- For part (d), some students tried to compute the following:

$$1 - P(\text{a bucket is empty}) - P(\text{a bucket has 2 or more elements})$$

There is some overlap between the two cases which were not properly identified.

- For part (e), some students treated n as both a bounded value and ∞ at the same time.

Question 3 (Nottingham Hashing) [4+2+2+2=10 (+3 Bonus) Marks]

- For part (a), marks were taken off for misplaced keys and incorrect probe distances.
- For part (b), some answers were not connected to probability and instead described the average distance instead of the expected probe distance. Additionally, some students' answers were not general enough.
- Parts (c) and (d) were answered well; marks were taken off if the wording for why deletion preserved the Nottingham Table structure was too vague.

Question 4 (Quadtrees) [5+5+5=15 Marks]

- For part (a), some students just gave the grid of quadrant divisions without also drawing the final tree.
- For part (b), incomplete/incorrect responses included not giving the final answer in terms of n (answers in terms of k) were given instead, or using base 4 rather than base 2.
- For part (c)[i], marks were taken off if the answer simply stated that the height would change without providing an explanation as to why this would occur.
- For part (c)[ii], many incorrect answers did not recognize that a quadtree with just 3 points could be arbitrarily large, and therefore the height differences between h and h' could be arbitrarily large as well.

Question 5 (Range Trees) [5+5+5=15 Marks]

- Part (a) was answered well in general. Marks were taken off if some trees were imbalanced or did not follow the BST ordering property.
- Parts (b) and (c) were generally well done. Some marks were deducted if answers did not include sufficient explanations for why the runtime requirements would be met. Some answers were also too vague, referencing blue (boundary) nodes from the course notes without explaining the significance of such nodes.