

Homework 6

Question 1. Head over to the <https://www.gutenberg.org> and find an interesting book that is available in the text format. Perform word frequency analysis on the text of the book using the Java's built-in **hash map**. Before you start any counting, make sure you clean your text of any characters that are not lower-case English alphabet or an invisible space character, visibly rendered as “_”. Print out the top ten words with their respective frequencies in descending order. The words should be *at least six letters*. For example, a sample output for the George Orwell's novel *1984* is given below. Place the code for this question in a file called Frequency.java and copy any output in your PDF to answer this question.

```
|   winston | 282|
| thought | 158|
| seemed  | 133|
| moment  | 131|
| always   | 122|
| obrien   | 119|
| almost   | 106|
| another  | 105|
| though   | 104|
| before   | 103|
```

Question 2. Let the 27 letter alphabet consist of a space and 26 lower case English letters: $\{_, a, b, c, \dots, z\}$. We may further order the alphabet with $f = \{(_, 0), (a, 1), (b, 2), (c, 3), (d, 4), \dots, (z, 26)\}$. A *hash* function h takes any arbitrary string s of the alphabet's characters to a non-negative integer. Let s be of length n where s_i is the i^{th} character of s , $h(s)$ is given as,

$$h(s) \equiv \sum_{i=0}^{n-1} (f(s_i) \times 27^i) \pmod{m}.$$

As trivial examples, for a sufficiently large value of m ,

$$h(_) \equiv 0 \equiv (0 \times 27^0), \quad h(a) \equiv 1 \equiv (1 \times 27^0), \quad h(b) \equiv 2 \equiv (2 \times 27^0) \pmod{m}.$$

And, for a non-trivial example,

$$\begin{aligned} h(\text{bobby}) &\equiv (f(\text{b}) \times 27^4) + (f(\text{o}) \times 27^3) + (f(\text{b}) \times 27^2) + (f(\text{b}) \times 27^1) + (f(\text{y}) \times 27^0) \pmod{m} \\ &\equiv (2 \times 27^4) + (15 \times 27^3) + (2 \times 27^2) + (2 \times 27^1) + (25 \times 27^0) \pmod{m} \\ &\equiv 1062882 + 295245 + 1458 + 54 + 25 \pmod{m} \\ &\equiv 1359664 \pmod{m} \end{aligned}$$

Write a Java program that takes $h(s)$ and prints out s , e. g., java Inverse 1359664 prints *bobby*. Use this program to figure out the string s for the following $h(s)$,

144644361721427313922062331675403123867343950242520475640707597283261643774925737501589409076350039814

Yes, you have to use BigInteger; you'll be okay.

Question 3. Download the professor's implementation of the above hash function in Java from the linked file [HashBrown.java](#). Also download the list of [370,105 unique English words](#). Write a program that finds all the hash collisions among these words for each m_i given below.

$$m_1 = 2^{31} - 1 = \text{Integer.MAX_VALUE}$$

$$m_2 = 2^{63} - 1 = \text{Long.MAX_VALUE}$$

For every hash collision corresponding to each m_i give the hash value and the collided words. E. g., there are 30 hash collisions when $m = 2^{31} - 1$ with one of them being $h(\text{decoy}) = 2226796 = h(\text{eternish})$. Use the main method of HashBrown.java for this question.

Question 4. Read Cormen, et al. *Introduction to Algorithms* (3rd Edition) pages 647–652 and pages 658–659. You'll be implementing the Dijkstra's and the Bellman-Ford¹ algorithms. Download the files containing the adjacency matrices,

- 1) `dijkstra1.txt`
- 2) `dijkstra2.txt`
- 3) `bellmanford1.txt`
- 4) `bellmanford2.txt`

The above matrices define edge weights between vertices that should be named by taking as many labels as the rows/columns in the list: a, b, c, ..., z.

Write a Java class `Graph.java` that implements both the Dijkstra's² and the Bellman-Ford algorithms. Use your Dijkstra's implementation to solve the files `dijkstra1.txt` and `dijkstra2.txt`. Similarly, use your Bellman-Ford algorithm to solve the files `bellmanford1.txt` and `bellmanford2.txt`. For each of the graphs and the algorithm, report the minimum distance with which each vertex can be reached and their respective parent vertex in your answers PDF. E.g, the output of Dijkstra's algorithm on `dijkstra1.txt` should look like,

```
a: 0 via a
b: 8 via d
c: 9 via b
d: 5 via a
e: 7 via d
```

You may verify the above by manually drawing the `dijkstra1.txt` graph on a piece of paper and running Dijkstra on it by hand.

Question 5. Can you run the Bellman-Ford algorithm on `dijkstra1.txt` and `dijkstra2.txt` to obtain the same result as you did by running the Dijkstra's algorithm? Similarly, can you run Dijkstra's algorithm on `bellmanford1.txt` and `bellmanford2.txt` to obtain the same results as you did by running Bellman-Ford algorithm?

Question 6. On a graph of exclusively positive edge weights, which algorithm is a better choice?

Question 7. Watch [A* \(A-Star\) Pathfinding Algorithm Visualization on a Real Map](#) on YouTube to see how a path finding algorithm known as the A* looks in execution on a real world graph. Note that A* is essentially the Dijkstra's algorithm with the addition of an “heuristic” function.

SUBMISSION INSTRUCTIONS

- 1) Turn in a PDF containing any outputs and answers from the homework.
- 2) Also turn in your `Frequency.java`, `Inverse.java`, `HashBrown.java` (with a main method) and finally the `Graph.java`.

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¹Also known as the “distance vector routing” algorithm in the networks field.

²Note that Java's class `PriorityQueue` is not `dynamic` and breaks ties arbitrarily.