**Theory (Max 15 Marks)**

**1. What is the difference between a linked list and an array, and when would you use one over the other? (1 Mark)**

**2.** What is a dictionary, stack, queue and when would you use it? (3 Marks)

**3.** A hash table is made up of two parts: an array (the actual table where the data to be searched is stored) and a mapping function, known as a hash function. The hash function is a mapping from the input space to the integer space that defines the indices of the array. In other words, the hash function provides a way for assigning numbers to the input data such that the data can then be stored at the array index corresponding to the assigned number. A hash table can insert, remove and search for data with O(1) complexity on average. A collision occurs when two or more values in the input space maps onto the same integer space. Thus having multiple values for the same key. You are tasked to implement a hash table. How would you

a) hash the value if the input is always a number?

b) hash the value if the input is always a string?

c) Handle collisions in your table? (5 Marks)

**4.** Choose one of the following data structures: Binary-Tree, AVL Tree, Splay Tree, Skip List. Write a description on your chosen data structure, explaining what it is, how it works, why it is useful, an example of execution and when you would use it. The description can be of any size, but penalties will occur if sections are left out. You do not need to cite sources. (10 Marks)

**Practical (Max 45 Marks)**

**Section A (Max 15 Marks)**

**Data Structures 1 (Choose one of the following) (3 Marks)**

**1.** A palindrome is a word, phrase, number, or other sequence of characters which reads the same backward or forward, such as “madam” or “racecar”. Capital letters and spaces do not break the palindrome property. “Dammit Im mad” is considered a palindrome. Given a string inputted from the user, write a program that would determine whether or not the given string is a palindrome. Your software should output “Yes” if the word is a palindrome and “No” if the word is not a palindrome. You may not use the built in reverse function of strings.

**2.** Write a program that reads in a sequence of characters, and determines whether its parentheses, braces, and curly braces are "balanced." Hint: for left delimiters, push onto stack; for right delimiters, pop from stack and check whether popped element matches right delimiter.

**Data Structures 2 (7 Marks) – File: datastructures2.csv**

Given files with contact information, write a program that can read, edit, find, add and remove records to the data as efficient as possible. The data can be stored in memory and does not need to be written to a file or a database. You do not need to provide a GUI. You get marked on insertion time, searching time, deleting time and space requirements for your algorithm. 2 Marks per property. The more efficient, the better the marks. You will receive no marks for a property if the time or space complexity exceeds O(n).

**Data Structures 3, Algorithms 1 (10 Marks) – File: datastructures3.csv**

Given a list of movies in a text file, read the data into memory, and using one of the following algorithms: Binary-Tree, AVL Tree, Splay Tree, Skip List, write a search function based on the title of the movie. Searching can be case sensitive. You get full marks if the algorithm is correctly implemented for all general cases. Losing marks for problem specific code, memory issues or cases not considered.

**Section B (Max 10 Marks)**

**Algorithms 0 (3 Marks)**

Write a program that takes as input a list of numbers and finds the average number of all given numbers.

**Algorithms 1 (7 Marks) – File: algorithms1.csv**

Given an unsorted number list of 5K numbers. Sort the list as fast as possible. Speed is a factor. Your marks are based on the relative speed of execution. You may not use the built in sorting function.

**Section C (Max 10 Marks)**

**Research (You may solve these problems in any way you wish)**

**Level 1 (3 Marks) – File: researchlv1.csv**

Given a string of digits in a file, work out the sum of the numbers.

**Level 2 Choose one (7 Marks)**

**File: researchlv2num1.csv**

**1.** When you misspell a word in Google, Google often corrects your spelling. Google uses a statistical based neural network to accomplish this. Neural networks are beyond the scope of this test. You would like to implement a similar feature in an app you design. Since you do not have as much training data as Google has, you instead decide to use a different method of searching. After careful consideration, you decide to either search using fuzzy logic or using a phonetic algorithm. Your task is to either implement a fuzzy search algorithm or a phonetic algorithm based on a dictionary of words. You will be marked on performance. GUI is not needed and will receive no marks for it.

**Files: countries.csv, mythical.csv, names.csv, professions.csv, sports.csv**

**2.** You are creating a RPG game with 100 000 NPCs, 10 000 mystical creatures, 5 000 new professions, 10 new sports and 50 new countries. You decide to give up on thinking of new names and decide to write a random word generator to use in this case. After you write your generator, the words simply do not make sense, coming out scrambled, like alsjkfhsfjoisogv. You decide to take a different approach and decide to build a name generator based on a Markov chain. In probability theory and statistics, a Markov chain is a process satisfies the property that one can make predictions for the future of the process based solely on its present state just as well as one could knowing the process's full history. Or in human language, given a sample of data, you can create new realistic looking sets of data based on existing data. Create a program that takes as input a text file used for the generation of the Markov chain, and outputs a set amount of randomly generated words using a Markov chain traversal technique. Data is provided. Full marks is awarded if your Markov chain is functional and properties can be changed. GUI is not needed and will receive no marks for it.

**Section D (Max 10 Marks)**

**Logic (You may solve these problems in any way you wish)**

**Easy (Choose 1) (3 Marks)**

**1.** Carl and his two friends have entered as a team for an upcoming cross country relay event. Each member may run only once, but may run as many laps as they like. Each lap a runner runs will take one minute more than the previous lap. Carl and his two friends each run their first laps in 3, 5 and 7 minutes respectively. Given the total number of laps to be run, what is the fastest time in which they can finish?

**Example**

Input the total laps: 9

Total running time is 50 minutes

Test your program with:

5 (1 mark)

15 (1 mark)

25 (1 mark)

**2.** To check whether an account number is genuinely a number allocated by the bank, the Pomme Bank of Paris uses the following technique. All the non-zero digits in the number are multiplied by each other. All the non-zero digits of the resulting number are again multiplied by each other – and so on until a single digit is left. That is the security digit.

Write a program that will provide the security digit for any number with up to 20 digits.

**Example 1:**

Input: Number? 469795

Output: Security digit = 8

**Example 2:**

Input: Number? 1234239003

Output: Security digit = 9

Record the results of the following test cases:

193 (1 Mark)

901090506 (1 Mark)

1567890123 (1 Mark)

**3.** A number is an ordered number when its digits are in an increasing sequence. For example 136 is an ordered number but 163 is not; 225 is an ordered number, but 252 is not. A single digit number is always ordered.

A square is a number obtained by multiplying a positive whole number by itself. 16 is a square (4x4).

Task:

Write a program that will print out all the ordered squares up to and including a given value (V). Separate the ordered squares by commas or spaces. V will be a positive whole number less than 100,000

**Example:**

Input: V = 30

Output: 1, 4, 9, 16, 25

Test your program with

V = 100

V = 1 000

V = 2 000

**Medium (Choose 1) (5 Marks)**

**1.** The sum of the primes below 10 is 2 + 3 + 5 + 7 = 17.

Find the sum of all the primes below two million.

Prime Algorithm – 2 Marks

Correct Answer – 3 Marks

**2.** The sequence of triangle numbers is generated by adding the natural numbers. So the 7th triangle number would be 1 + 2 + 3 + 4 + 5 + 6 + 7 = 28. The first ten terms would be:

1, 3, 6, 10, 15, 21, 28, 36, 45, 55, ...

Let us list the factors of the first seven triangle numbers:

1: 1

3: 1,3

6: 1,2,3,6

10: 1,2,5,10

15: 1,3,5,15

21: 1,3,7,21

28: 1,2,4,7,14,28

We can see that 28 is the first triangle number to have over five divisors.

What is the value of the first triangle number to have over five hundred divisors?

Correct Answer – 5 Marks

**3.** The following iterative sequence is defined for the set of positive integers:

n → n/2 (n is even)

n → 3n + 1 (n is odd)

Using the rule above and starting with 13, we generate the following sequence:

13 → 40 → 20 → 10 → 5 → 16 → 8 → 4 → 2 → 1

It can be seen that this sequence (starting at 13 and finishing at 1) contains 10 terms. Although it has not been proved yet (Collatz Problem), it is thought that all starting numbers finish at 1.

Which starting number, under one million, produces the longest chain?

Algorithm – 2 Marks

Correct Answer – 3 Marks

**Hard (Choose 1) (10 Marks)**

**1.** A robot is sitting somewhere in an MxN grid of cells (M columns, N rows). It receives and interprets a string of instructions. The instructions are u (up), d (down), l (left) and r (right). If a robot can move in the direction specified, it moves one cell in this direction. However, if it is already at the boundary, it ignores the instruction.

A known string of instructions has been sent to the robot, but since you don’t know where it started, you have no idea where it has moved to. You can issue some further instructions that will move it to a precise location that is independent of the robot’s starting position. Write a program that will work out the fewest extra instructions required to move it to such position.

Ex. The robot starts in an unknown position in a grid of 5 columns and 4 rows. The robot receives an instruction list of left, up, left, down, right, down. The robot then attempts to follow the instructions ignoring those that would result in leaving the grid. If you send the robot 4 additional instructions (down, right, right, right) then it will be in the bottom right corner regardless of where it started.

Input

Enter the width M: 5

Enter the height N: 4

Enter the initial instructions: luldrd

Output

You need to issue a further 4 instructions.

Test with

1 1 lrudlrudlu (1 mark)

100 100 lrudrudludlrdlru (3 marks)

32 16 lllllllllllllllllllllllllllllluuuuuuuuuuuuuuuudddddddddddddddd (30\*l, 16\*u, 16\*d) (3 marks)

1000 3 ulrd (3 marks)

**2.** Six cities, A, B, C, D, E and F are connected by toll roads. Some roads can be zero toll roads. Write a program to work out the cheapest route to visit each city once only, starting at A and ending at A, and give the total toll to be paid. If there is more than one cheapest route, you may provide any one of them as answer. You may travel a road in any direction. The tolls are given in the following order:

A-B; A-C; A-D; A-E; A-F; B-C; B-D; B-E; B-F;C-D; C-E; C-F; D-E; D-F; E-F

**Example 1:**

Input: (in Rand) 6, 3, 2, 3, 10, 1, 6, 7, 4, 5, 1, 5, 10, 7, 3

Output: A D C B F E A, 18

**Example 2:**

Input: (in Rand) 10, 15, 7, 10, 7, 7, 9, 6, 7, 11, 12, 8, 5, 14, 9

Output: A D E B C F A, 40

Record the results of the following test cases:

9, 8, 7, 6, 5, 4, 3, 2, 1, 2, 3, 4, 5, 6, 7 (3 Marks)

6, 0, 7, 0, 8, 0, 1, 2, 3, 0, 5, 6, 7, 8, 9 (3 Marks)

12, 10, 14, 4, 11, 7, 2, 2, 10, 3, 6, 9, 8, 10, 1 (4 Marks)

**3.** The Froogons have made contact with Earth! Their advanced technology has made communication easy, except for their weird number system. They use factorials. N factorial, written as N!, is equal to 1 x 2 x 3 x … x N. For example, 3! = 1 x 2 x 3 = 6 and 1! = 1.

The Froogons write a number as a sequence where the first number from the left indicates the number of 1!s, the second number from the left indicates the number of 2!s, the third number indicates the number of 3!s, etc, The i-th number in the sequence is at most i and represents how many i!s are included in the number. For example, the 3rd number in the sequence is at most 3 and represents how many 3!s are included in the number.

Write a program that asks for an integer number as input and outputs its Froogon representation.

Input: A single positive integer N, in decimal notation.

Output: N written in Froogon notation. Your answer should be on a single line with a single space separating adjacent numbers in the sequence. Leading zeros must be shown.

Examples

Input: 13

Output: 1 0 2

Input: 17

Output: 1 2 2

Input: 24

Output: 0 0 0 1

In Froogon, 13 is written as 1 0 2 (i.e. 1 x 1! + 0 x 2! + 2 x 3!).

In Froogon, 17 is written as 1 2 2 (i.e. 1 x 1! + 2 x 2! + 2 x 3!).

In Froogon, 24 is written as 0 0 0 1 (i.e. 0 x 1! + 0 x 2! + 0 x 3! + 1 x 4!).

Test your program with the following numbers

18 (3 Marks)

719 (3 Marks)

2100100100 (4 Marks)

**DB Design (10 Marks)**

Driving down the road, you see some random people waiting for someone to pick them up and ask them to do some paid work. There has got to be a better way. You decide to write an app to assist with this problem. You as a user would log into the app with some informal work you need to have done. Eg. Painting, tiling, building etc. You make an offer for the amount you will pay for the work and the date you require the worker for. An informal worker will be assigned to you (by a third party) that has the needed skill you need and is available on the selected date. The phones GPS picks up your location and assigns the closest qualified worker to do your work. Once the work is complete, the amount is subtracted from your credit card and you are asked to rate and comment the worker. The worker would get a FNB cashback number or a code to receive the payment at Checkers or Pick ‘n Pay. Design a database for the solution. User profiles, jobs, workers etc. You do not need to consider API calls. You would like to keep stats on the workers, amount paid, work done.