# CS211FZ (Algorithms & Data Structures 2)

## Assignment 3

**Released date:** Sunday, 20th April 2025

**Deadline:** Friday, 2nd May 2025, at 18:00 Beijing time

This is an open-book, graded assignment. You may only use the module's slides and textbooks to help with the Assignment. Please cite all references as comments in your submissions. You cannot directly reuse a solution from online sources. You must not engage with another student, in person or electronically (via phone, social media, etc.), to secure assistance with this Assignment. If you do so (even for only one of the questions), you will receive an automatic failure (0%), and it will also be reported to the Executive Vice-Dean of MIEC and/or Maynooth University Plagiarism board. We will perform similarity checks on submitted assignments to check for collaborative efforts. The lecturer reserves the right to interview you about your submission in special cases.

## Direct-address tables

### Question 3.1

A dynamic set S is represented by a direct-address table $T$ of length $m$. Describe a procedure that finds the maximum element of $S$. What is the worst-case performance of your procedure? **[10 Marks]**

## Hash tables

### Question 3.2

Consider a hash table with 9 slots and the hash function $h(k) = k \bmod 9$. Demonstrate what happens upon inserting the keys 5, 28, 19, 15, 20, 33, 12, 17, 10 with collisions resolved by chaining. **[10 Marks]**

### Question 3.3

You need to store a set of $n$ keys in a hash table of size $m$. Show that if the keys are drawn from a universe $U$ with $|U| > (n - 1)m$, then $U$ has a subset of size $n$ consisting of keys that all hash to the same slot, so that the worst-case searching time for hashing with chaining is $\theta(n)$. **[10 Marks]**

## Hash functions
### *Question 3.4*

You wish to search a linked list of length $n$, where each element contains a key $k$ along with a hash value $h(k)$. Each key is a long character string. How might you take advantage of the hash values when searching the list for an element with a given key? **[10 Marks]**

### *Question 3.5*

Consider a hash table of size $m = 1000$ and a corresponding hash function $h(k) = \lfloor m(k \, A \bmod 1) \rfloor$ for $A = (\sqrt{5} - 1)/2$. Compute the locations to which the keys 61, 62, 63, 64, and 65 are mapped. **[10 Marks]**

## Open Addressing
### *Question 3.6*

Consider inserting the keys 10, 22, 31, 4, 15, 28, 17, 88, 59 into a hash table of length $m = 11$ using open addressing. Illustrate the result of inserting these keys using linear probing with $h(k, i) = (k + i) \bmod m$ and using double hashing with $h_1(k) = k$ and $h_2(k) = 1 + (k \bmod (m - 1))$. **[10 Marks]**

## Programming question
### *Question 3.7*

Write a program that indicates whether or not a number is a prime number, with the following considerations:

- The range of the numbers that the program need to check if they are prime is from 0 to 10000.
- The user wants to check $n$ numbers to see if they are prime number.
- You need to create a sufficient algorithm to solve the problem.

Hint: You can use Direct-address tables to solve the problem. **[40 Marks]**

### Important submission details

**Please indicate the Operating System (Linux/Windows/MacOS/Online), IDE (e.g. Eclipse, Visual Studio Code), and Java SDK version used for testing in your submission. If you use an online IDE, please specify the IDE (http://repl.it) and provide a link where possible.**

All work must be submitted via Moodle (see "Assignments" section for submission). Work submitted via other means will not be accepted unless you have prior arrangements with the lecturer. All work MUST be submitted by the due date deadline. Late submissions will not be accepted.

**Your submission should be one single PDF file, also including your Java codes. Submitting in any other format cannot be accepted.**

**Note:** You should type your answers in a text editor like Microsoft Word, and then convert it to PDF. You MUST NOT take pictures from answers and then make a PDF from the pictures.