Northeastern University
College of Engineering
Department of Electrical & Computer Engineering

EECE7205: Fundamentals of Computer Engineering

Homework 3

Instructions

- For programming problems:
  - Your code must be well commented by explaining what the lines of your program do. Have at least one comment for every 4 lines of code.
  - You are **not** allowed to use any advanced C++ library unless it is clearly allowed by the problem. For example, you cannot use a library function to sort a list of data if the problem is asking you to implement an algorithm to sort the list.
  - At the beginning of your source code files write your full name, students ID, and any special compiling/running instruction (if any).
  - Your code must compile and tested with a standard GCC compiler (available in the CoE Linux server). before submitting the source code file(s) (do not submit any compiled/executable files):
    a. If your program does not compile with a GCC compiler due to incompatible text encoding format, then make sure the program is saved with Encoding Unicode (UTF-8). In visual studio, Save As -> Click on the arrow next to Save -> Save with Encoding -> Yes -> Unicode (UTF-8) -> Ok
    b. Compile using g++ -std=c++11 <filename>

- Submit the following to the homework assignment page on Canvas:
  - Your homework report developed by a word processor and submitted as <u>one</u> PDF file. For answers that require drawing and if it is difficult on you to use a drawing application, which is preferred, you can neatly hand draw the answer, scan it, and include it into your report. The report includes the following (depending on the assignment contents):
    a. Answers to the non-programming problems that show all the details of the steps you follow to reach these answers.
    b. A summary of your approach to solve the programming problems.
    c. The screen shots of the sample run(s) of your program(s).
  - Your well-commented programs source code files (i.e., the .cc or .cpp files).

  Do NOT submit any files (e.g., the PDF report file and the source code files) as a compressed (zipped) package. Rather, upload each file individually.

<u>Note</u>: You can submit multiple attempts for this homework, however, only what you submit in the last attempt will be graded. This means all required files must be included in this last submission attempt.

Problem 1 (30 Points)

Assume we have a hash table with *m* = 11 slots, and suppose nonnegative integer key values are hashed into the table using the following hash function *h1*():

```
int h1(int key) {
 int x = (key + 5) * (key + 5);
 x = x / 16;
 x = x + key;
 x = x % 11;
 return x;
}
```

The sequence of 12 integer key values listed in the left table below are to be inserted in the hash table, in the order given. Suppose that collisions are resolved by using linear probing.

- On the left table below, show the probe sequence (the sequence of slots to be probed until an empty one, if any, is available) for each key.
- On the right table below, show the final contents of the hash table after the insertion process is complete.

No programming code is required for this problem.

Key Value	Probe Sequence
43	
23	
1	
0	
15	
31	
4	
7	
11	
3	
5	
9	

	Final Hash Table Contents
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

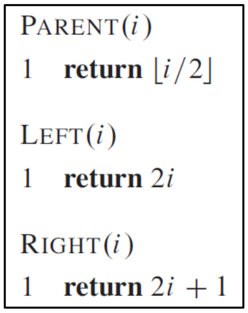
Problem 2 (40 Points)

Write a C++ program to study how the hash table size affects the collision rate. The following are the requirements of this program:

a. Generate 1000 random integers that represent the birthdays of people who were born between January 1, 2000 and December 31, 2004 in the format *mmddyy* (only five digits if *mm* is less than 10). An example of such integers is 112303 for someone who was born on November 23, 2003. For simplicity, assume that all people were born before the 28th day of their birth month and do not worry about duplicate birthdays.
b. Define three hash tables with the following sizes: m_1 = 97, m_2 = 98, and m_3 = 100.
c. Simulate storing the 1000 random birthdays that you generate in step *a* in each of the three hash tables using hash function $h(k) = k \bmod m_i$. Where *k* is the birthday integer and m_i is the size of table *i* (i = 1, 2, 3). Assume that collision is resolved by chaining. You do not need to generate the actual chains in your program. Instead store in each slot of the table, the number of birthdays values that are mapped to that slot. Note that, at the end, if a slot of the table has the value *x*, this means there was (*x*-1) collisions on that slot.
d. For each one of the three tables, calculate the minimum, maximum, mean, and variance of the collision values stored in the table from step c.
e. Comments on the results you calculated in step *d* by explaining how the hash table size affects the collision rate.

Problem 3 (30 Points)

If the root of a complete tree starts at index 1 and given the index *i* of a node, prove mathematically that the formulas used in the following functions are correct and they will return the indices of that node's parent, left child, and right child.



```
PARENT($i$)
    return $\lfloor i/2 \rfloor$

LEFT($i$)
    return $2i$

RIGHT($i$)
    return $2i + 1$
```