CS211FZ (Algorithms & Data Structures 2)

CA1 – this lab is worth 5% of the module marks and is marked out of 100

Due: Friday 4th April. 1pm

This is an open-book, graded 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.
IMPORTANT: You must demonstrate your software to a TA and answer any questions before the end of the lab session to get the Programming Marks. So it is suggested you do the final 2 programming questions first. Software templates are available on Moodle but you don't have to use them. You must also submit your programs in the pdf submission, submitted as one Class.

Question 1-1

What is the smallest value of n such that an algorithm whose running time is $50n^2$ runs faster than an algorithm whose running time is 2^n on the same machine? **[5 marks]**

Question 1-2

Comparison of running times

For each function $f(n)$ and time t in the following table, determine the largest size n of a problem that can be solved in LESS THAN time t, assuming that the algorithm to solve the problem takes $f(n)$ seconds. Small errors are acceptable. (Hint: You could solve these mathematically or write java code to solve them. Question 1-12 requires this so it may be useful to check that question first). **[20 Marks]**

(lg n is log to the base 2 of n)

(a month is 30 days)

(a year is 365 days)

	1 second	1 Minute	1 Hour	1 Day	1 Month	1 Year
$\lg n$	1		Overflow	Overflow	Overflow	Overflow
$\sqrt{n}$	0					Overflow
n	0	59	3,599	86,399	2.591,999	31535999
$n \lg n$	0					
n^2	0	7				
n^3	0	3				
2^n	0					
$n!$						

Question 1-3

Express the function *($n^3/1000 - 100n^2 - 100n + 3$)* in terms of Θ-notation and explain why. **[5 marks]**

Question 1-4 Ordering by asymptotic growth rates

Rank the following functions by order of growth. That is, find an arrangement $g_1, g_2, \ldots, g_{30}$ of the functions satisfying $g_1 = \Omega(g_2)$, $g_2 = \Omega(g_3)$, $\ldots$, $g_{29} = \Omega(g_{30})$. Partition your list into equivalence classes such that functions $F(n)$ and $g(n)$ belong to the same class if and only if $f(n) = \Theta(g(n))$. **[15 Marks]**

		$(\sqrt{2})^{\lg n}$	n^2	$n!$	$(\lg n)!$
$(3/2)^n$	n^3	$\lg^2 n$	$\lg(n!)$	2^{2^n}	
$\ln \ln n$		$n \cdot 2^n$	$n^{\lg \lg n}$	$\ln n$	1
$2^{\lg n}$	$(\lg n)^{\lg n}$	e^n	$4^{\lg n}$	$(n+1)!$	$\sqrt{\lg n}$
	$2^{\sqrt{2 \lg n}}$	n	2^n	$n \lg n$	$2^{2^{n+1}}$

Question 1-5

Let *f(n)* and *g(n)* be asymptotically nonnegative functions. Using the basic definition of Θ-notation, explain in simple terms why *max(f(n), g(n)) = Θ(f(n) + g(n))*. **[5 Marks)**

Question 1-6

a) Is $2^{n+1} = O(2^n)$?
b) Is $2^{2n} = O(2^n)$?

[5 marks]

Question 1-7

Explain why $o(g(n)) \cap \omega(g(n))$ is the empty set.

[5 marks)

Programming Questions

You may find it helpful to use the Java templates supplied on Moodle

Question 1-8

Create a simple Higher or Lower game in Java. You code should
1. Create a random integer between 1 and 10,000.
2. Ask the user to input a number as their guess.
3. If the user's guess matches the random number, it displays 'Correct' and stops.
4. If the user's guess is higher than the random number, it displays 'Lower' and prompts for another guess.
5. If the user's guess is lower than the random number, it displays 'Higher' and prompts for another guess."
Code template in moodle as Guess_template.java

[20 marks)

Question 1-9

Revisit question 1-2 and write a java program that solves $n*\log_2(n) < t$ for any value of t. You will need to use binary search since there's no simple closed-form solution.

[20 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, including also your Java codes. Submitting in any other format cannot be accepted.