University of Glasgow

Wednesday 28 April 2021
Available from 09:15 BST
Expected Duration: 1 hour 30 minutes
Time Allowed: 3 hours
Timed exam within 24 hours

DEGREES OF MSci, MEng, BEng, BSc, MA and MA (Social Sciences)

ALGORITHMS AND DATA STRUCTURES 2
COMPSCI2007

Answer all 5 questions

This examination paper is an open book, online assessment and is worth a total of 60 marks

1. Algorithm **F** takes as input an array of integers A and two indices p, r of A. It is described by the following pseudocode:

```
1: F(A, p, r)
2:   if p < r
3:     x := A[p]
4:     A[p] := A[r]
5:     A[r] := x
6:     F(A, p + 1, r − 1)
```

(a) Briefly explain what algorithm **F** implements. [5]

(b) What is the output of $\mathbf{F}(A, 0, 6)$, where $A = [1, 5, 7, 9, 3, 4, 1]$? [2]

(c) Draw the recursion trace for $\mathbf{F}(A, 0, 6)$. [3]

(d) Is **F** tail recursive? Justify your answer. [2]

(e) Is **F** an in-place algorithm? Justify your answer. [2]

(f) Write an iterative version of algorithm **F** and compute its complexity. Suppose n is the size of the input array. Use big-Oh notation. [6]

2. For each of the following statements, prove whether it is true or false.

(a) $29 = O(\log_2 n)$ [3]

(b) $\max(n^3, 10n^2) = O(n^2)$ [3]

3. **(a)** Briefly describe using your own words the counting sort algorithm (expected word count: 100). Illustrate your description by sorting the list: 3, 7, 4, 2, 1, 5, 4. [6]

(b) Briefly describe using your own words the radix sort algorithm (expected word count: 50). Illustrate your description by sorting the list: 802, 256, 958, 938, 693, 405, 684, 854. [6]

4. Illustrate the result of each operation in the sequence PUSH(S, 5), PUSH(S, 2), PUSH(S, 4), POP(S), PUSH(S, 7), and POP(S) on an initially empty stack S. Consider the following two cases:

(a) Stack S is implemented by array $S[0..5]$. [3]

(b) Stack S is implemented by a linked list. [3]

5. **(a)** Briefly explain with your own words what a hash table is, its main components and its operations? Expected word count: 100. [3]

(b) Briefly explain with your own words what a *hash collision* is and give an example application for which hash table storage would be suitable. Expected word count: 50. [3]

(c) Briefly describe with your own words the chaining method of hash collision resolution and give one advantage of this method. Expected word count: 70. [2]

(d) Show the resulting hash table if keys 5, 28, 19, 15, 20, 33, 12, 17, 10 are inserted into an initially empty hash table assuming collisions are resolved by chaining. Suppose the table has 9 slots, and let the hash function be $h(k) = k \mod 9$. [3]

(e) Briefly describe with your own words the open addressing method of hash collision resolution. Expected word count: 70. [2]

(f) Show the resulting hash table if keys 50, 700, 76, 85, 92, 73, 101 are inserted into an initially empty hash table assuming collisions are resolved by open addressing with *linear probing*. Suppose the table has 7 slots, and let the hash function be $h(k) = k \mod 7$. [3]

END OF QUESTION PAPER