

# Ph.D. Comprehensive Examination

Computer Science Department  
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Student Name:

Student Number:

Problem number	Points (10 max)
1	
2	
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Total:	

**1. I.A Data organization; III.A Algorithms and complexity**

Each item  $x$  in a set  $S$  has a unique key  $key[x]$ . We need to implement the following operations.

- (a) Search  $(S, key)$
- (b) Insert  $(S, x)$
- (c) Successor  $(S, x)$
- (d) Predecessor  $(S, x)$

Give the 4 running times as an  $O()$  for the following implementations:

- (a) Ordered (sorted) array,
- (b) Ordered doubly linked list,
- (c) Min-Heap, and
- (d) Hash table

**2. I.B Program control and structure; I.C Programming language and notations**

Suppose that procedure *swap* is declared as follows:

```
procedure swap( x, y: integer);  
  procedure f(): integer;  
    var z: integer;  
    begin // f  
      z = x; x = y; return z;  
    end // f  
  begin // swap  
    y = f();  
  end // swap
```

Describe the effect of the procedure call *swap*(*i*, *A*[*i*]) under each of the following parameter passing methods:

- (a) Call-by-value
- (b) Call-by-reference
- (c) Call-by-value-result

**3. I.D Software engineering**

From the software engineering point of view, any software development process can be divided into several sub-disciplines:

- (a) Requirement Analysis
- (b) Functional Specification
- (c) Architectural Design
- (d) Implementation
- (e) Testing and Evaluation
- (f) Maintenance

Choose three sub-disciplines or tasks within these sub-disciplines that involve a mathematical approach, and illustrative them with examples.

## 4. I.E Systems

- (a) \_\_\_\_\_ linked libraries can support shared library code, allowing one copy of a library routine to be used by several different processes.  
**absolute    relative    static    dynamic    none of these is correct**
- (b) When it is not known at compile time where a process will reside in memory, \_\_\_\_\_ code must be generated.  
**logical    physical    absolute    relocatable**
- (c) A UNIX process calls *fork()* to create a child process as shown: *pid = fork()*;  
i. What value will be assigned to *pid* in the parent process by the call to *fork()*?  
**the parents process id    the childs process id    zero none of these**  
ii. What value will be assigned to *pid* in the child process by the call to *fork()*?  
**the parents process id    the childs process id    zero none of these**
- (d) The Banker's algorithm is used for deadlock \_\_\_\_\_.  
**denial    prevention    avoidance    recovery**
- (e) Belady's anomaly can affect the performance of the \_\_\_\_\_ page replacement algorithm.  
**FIFO    LRU    optimal    SJF**
- (f) \_\_\_\_\_ access files are made of fixed length records that allow programs to read and write records in no particular order.  
**sequential    direct    logical    none of these is correct**
- (g) When an I/O request is being handled for a users process, which term refers to the policy of returning control to the user process before the I/O is completed?  
**synchronous I/O    asynchronous I/O    delayed I/O    none of these**
- (h) Which multithreading model requires that a new kernel thread be created for each new user thread?  
**many-to-one    one-to-one    many-to-many    none of these is correct**
- (i) A process that does not affect, and is not affected by, another process is referred to as:  
**static    independent    cooperating    dynamic    unbounded**

**5. II Computer Organization**

- (a) Draw an architecture of a quad-core processor and discuss the role of each module in your diagram.
- (b) Find a binary representation of the decimal number 0.1.

**6. II.D Networking and Communications**

- (a) Draw a diagram showing layers of the Internet Protocol Stack and briefly discuss role of each layer.
- (b) Describe functions of each layer when a file is transferred from a source to destination using (*file transfer protocol* (FTP)).

**7. III.A Algorithms and complexity**

Describe an algorithm that takes two input lists of integers  $A = a_1, \dots, a_n$  and  $B = b_1, \dots, b_m$  and delivers the list of all the elements that belong to  $A$  but not to  $B$ .  $A$  and  $B$  do not contain redundant elements, however, the elements of  $A$  and  $B$  might have a large range.

The algorithm should run in  $O(n \log m + m \log m)$  time.



**8. Automata and language theory**

Consider the following grammar:

$$G \longrightarrow S \$ \$$$

$$S \longrightarrow A M$$

$$M \longrightarrow S \mid \epsilon$$

$$A \longrightarrow a E \mid b A A$$

$$E \longrightarrow a B \mid b A \mid \epsilon$$

$$B \longrightarrow b E \mid a B B$$

- (a) Describe the language that the grammar generates in English.
- (b) Show a parse tree for the string **a b a a**.
- (c) Is the grammar LL(1)? If so, show the parse table; if not, identify a prediction conflict.

**9. III.C Discrete Structures**

Recall that the Hamiltonian Cycle Problem is the problem of deciding, on input graph  $G$ , whether  $G$  has a cycle that visits all the nodes exactly once. Show that this problem is polynomial time decidable if the input is restricted to the graphs with the property that each node has at most two neighbors (i.e., at most two adjacent nodes).

**10. IV Other Topics**

Give a detailed explanation of any one approach to machine learning. Give a substantial example that illustrates the technical operation of the approach, and demonstrates interesting knowledge learned.