

# Ph.D. Comprehensive Examination

Computer Science Department  
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Student Name:

Student Number:

Problem number	Points (10 max)
1	
2	
3	
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5	
6	
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10	
Total:	

**1. Data organization; 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. Program control and structure; 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. 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. 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 parent's process id    the child's process id    zero    none of these**
- ii. What value will be assigned to *pid* in the child process by the call to *fork()*?  
**the parent's process id    the child's 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 user's 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. Software, Programming Techniques**

Given that

$B(x)$  means "x is a bear"

$F(x)$  means "x is a fish", and

$E(x, y)$  means "x eats y",

what is the best English translation of

$\forall x[F(x) \rightarrow \forall y(E(y, x) \rightarrow B(y))]$ ?

- (a) All fish eat bears.
- (b) Every fish is eaten by some bear.
- (c) Bears only eat fish.
- (d) Every bear eats fish.
- (e) Only bears eat fish.

**6. 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. 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. Discrete Structures**

A **permutation** of a set  $A$  is an *ordered* arrangement of the elements in  $A$ . An ordered arrangement of just  $r$  elements from  $A$  is called an  $r$ -permutation of  $A$ . For non-negative integers  $r \leq n$ ,  $P(n, r)$  denotes the number of  $r$ -permutations of a set with  $n$  elements.

What is  $P(n, r)$ ? This is about counting.

**10. Other Topics**

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