Entrance exam - Computer Science

Name and Surname – fill in the field	*Application No.*	*Test Sheet No.*
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Algorithms and Data Structures

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1 Consider a hash table with linear probing, and the hash function *h(x) = (5*x + 3) mod 7*. We start with an empty hash table. In which order do we have to insert the values 1, 2, 5, 7, 9, 12 so that the contents of the resulting hash table is as follows: 2, 12, 1, 5, 7, empty field, 9?

***A** 9, 2, 12, 1, 5, 7
B 2, 9, 5, 12, 1, 7
C 9, 2, 5, 12, 1, 7
D 9, 2, 12, 5, 1, 7
E 2, 9, 12, 5, 1, 7

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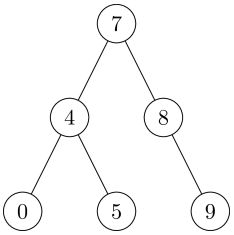
2 Consider a binary search tree (BST) containing *n* elements, and the following four operations: SEARCH (find a given element in the BST), INSERT (insert an element into the BST), REMOVE (remove an element from the BST) and ROOT (return the value of the root element of the BST). How many of these four operations have *linear worst-case* time complexity?

A 1
B 0
C 2
D 4
***E** 3



3 Consider the tree depicted above. In how many ways can we assign red and black colours to the vertices so that the result is a correct red-black tree?

A There are four ways.
B There is only one way.
***C** There are two ways.
D There are eight ways.
E There is no way to do that.

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4 Consider a directed graph. We run a depth-first search on this graph; the search assigns to each vertex *v* two numbers: *v.d* is the discovery time of *v*, *v.f* is the finishing time of *v*. Which one of these statements is true in general?

A If there is a path from vertex *u* to vertex *v* in the graph, then $u.d < v.d$.
B If there is a path from vertex *u* to vertex *v* in the graph, then $u.d > v.d$.
C If there is a path from vertex *u* to vertex *v* in the graph, then $u.f < v.f$.
***D** None of the other statements is true in general.
E If there is a path from vertex *u* to vertex *v* in the graph, then $u.f > v.f$.

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5 Which one of these statements is true?

A B-trees are a special case of binary search trees.

B The function n^n grows asymptotically as fast as the function $n!$.

***C** We cannot efficiently (i.e. with sublinear time complexity) search for a given element in a binary heap.

D The mergesort algorithm is a stable, in situ (in place) sorting algorithm with time complexity in $\mathcal{O}(n \log n)$.

E The worst-case time complexity of inserting an element into a hash table is in $\mathcal{O}(1)$.

Computer Systems

6 Which one of the following entities **is not** used to convert a logical (virtual) address to a physical address in the protected mode of Intel (and compatible) desktop processors?

A descriptor table
B linear address
C page table
***D** DMA (Direct Memory Access) unit
E page directory

7 Assume a multiplexer logic circuit with 16 *data* inputs. What is the number of *all* its inputs?

A 16
B 18
C 24
D 32
***E** 20

8 Which binary number in two's complement is equivalent to the decimal number -88?

A 11101010
B 10001010
C 10100111
***D** 10101000
E 11011000

9 One DRAM memory cell serves for storage of one data bit. The cell is wired up using:

***A** one transistor and one capacitor.
B one capacitor.
C one transistor and one resistor.
D two transistors and one capacitor.
E one bistable flip flop circuit.

10 Which one of the following statements about multitasking in operating systems is **not** valid:

A Cooperative multitasking is a style of computer multitasking in which the operating system never initiates a context switch from a running process to another process.
B Preemptive multitasking is a style of computer multitasking in which the operating system kernel can initiate a context switch to satisfy the scheduling policy's priority constraint.
C Preemptive multitasking involves the use of an interrupt mechanism.
***D** Cooperative multitasking allows the computer system to more reliably guarantee each process a regular "slice" of operating time.
E Cooperative multitasking is a style of computer multitasking in which the processes voluntarily yield control periodically or when idle in order to enable multiple applications to be run simultaneously.

Programming

11 Which of the following three statements I, II, and III are true (in common languages such as C++, Java, C#). Choose the option that contains exactly all the true statements (and none of the false ones).

I. Local variables of functions are allocated on the heap. They are automatically de-allocated when leaving the function.

II. Function calls are implemented using the stack and the stack contains the return values of functions.

III. If an exception is caught (in a `catch` block), it can be re-thrown (using `throw`).

A I, III
B II, III
***C** III
D I, II, III
E I, II

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12 Assume this program, where `mod` is the modulo operator and `div` is the integer division operator.

```
read(n)
sum = 0
k = n
XXX {
        sum = sum + (n mod 10)
        n = n div 10
}
print sum
```

A positive integer is given on input and read into `n`. Which one of the following can be placed instead of "XXX" in the code above, so the code computes the sum of decimal digits of the given integer?

A `while n == k`
B None of the other options is true.
C `while n > sum`
D `for i = 1 to 10`
***E** `for i = 0 to k`

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13 Which statement is generally true in common OOP languages (C++, Java, C#):

A If a class B inherits from a class A, B can access all attributes (member variables) of A.
B If late binding (virtual method calls) is used, the actual method to be called is decided by the compiler at compile time.
C The difference between a class and an object is that classes are allocated on the heap while objects are allocated on the stack.
***D** None of the other statements is true.
E Static methods (member functions) can be virtual.

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14 Which one of the following statements is **false**?

A In purely functional languages, functions can have no side effects.
B A tail-recursive function can always be rewritten in an iterative manner.
***C** Haskell is not a purely functional language, because it allows I/O operations.
D The lazy evaluation strategy in functional programming allows working with infinite data structures.
E A recursive function can always be rewritten in an iterative manner.

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15 Assume this program, where the function `print` outputs the passed number followed by the new line character.

```
function foo(integer n)
begin
        print n
        if n > 0 then
                foo(n-1)
                print n
                foo(n-1)
                print n
        end if
end

program main()
begin
        foo(3)
end
```

How many lines are going to be printed by the program?

A None of the other options is true.
B 7
C 30
***D** 29
E The program will run forever and never halt.

Computer Networks

16 Self-correcting codes used during data transmission allow the receiver:

A to inform the sender about errors incurred during the data transmission and to ask for retransmission of errorneously transmitted data.
***B** to detect very-likely errors incurred during the data transmission and to correct most of them.
C only to inform the sender about errors incurred during the data transmission.
D only to detect most errors incurred during the data transmission.
E to detect and correct all errors incurred during the data transmission.

17 An application for electronic mail (e-mail) uses:

***A** the protocol SMTP to deliver the message to a local mail-server and then from the local mail-server to the target mail-server, and the protocol POP3 or IMAP4 to download or read the message.
B the protocol IMAP4 to deliver the message from a local mail-server to the target mail-server, and the protocol POP3 to download or read the message.
C the protocol POP3 to deliver the message from a local mail-server to the target mail-server, and the protocol SMTP to download or read the message.
D the protocol POP3 or IMAP4 to deliver the message from a local mail-server to the target mail-server and to download or read the message.
E the protocol POP3 or IMAP4 to deliver the message from a local mail-server to the target mail-server.

18 Transport Control Protocol (TCP) provides a fully guaranteed data transportation including congestion and flow control. This protocol transports a message by splitting it into packets. The packets are numbered, where the number of each packet is derived from:

***A** a randomly-generated seed plus the offset of the byte in the message that corresponds to the first byte of the packet.
B zero plus the offset of the byte in the message that corresponds to the first byte of the packet.
C a randomly-generated seed plus the offset of the bit in the message that corresponds to the first bit of the packet.
D a randomly-generated seed incremented by one for each transmitted packet.
E a randomly-generated seed plus the offset of the byte in the message that corresponds to the last byte of the packet.

19 To access a particular service on a target node in the Internet, it is necessary to know:

A the IP address.
***B** the IP address and the port number.
C the MAC address.
D the port number.
E the MAC address, the IP address and the port number.

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20 Omnidirectional wireless transmission spreads the emitted energy in all directions. The received energy by the receiver:

A decreases cubically with the increasing distance of the receiver from the transmitter.
B decreases linearly with the increasing distance of the receiver from the transmitter.
C decreases exponentially with the increasing distance of the receiver from the transmitter.
D is identical to the emitted energy regardless of the distance of the receiver from the transmitter.
***E** decreases quadratically with the increasing distance of the receiver from the transmitter.

Database Systems

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21 Choose the valid sequence of states via which a database transaction can pass through.

A active → failed → partially committed → aborted
B active → partially committed → failed → committed
C active → partially committed → partially rollbacked → completed
D active → committed → aborted
***E** active → partially committed → failed → aborted

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22 An e-shop application contains a non-empty relation *product(id, name, amount, price, category)*. Its primary key is the attribute *id*.
Which one of the following SQL commands returns the same result as:

SELECT AVG(price * amount) FROM product GROUP BY id;

A SELECT AVG(price * amount) FROM product;
B SELECT AVG(price) * AVG(amount) FROM product;
***C** SELECT price * amount FROM product;
D SELECT SUM(price * amount) / COUNT(*) FROM product;
E SELECT SUM(price) * SUM(amount) / COUNT(id) FROM product;

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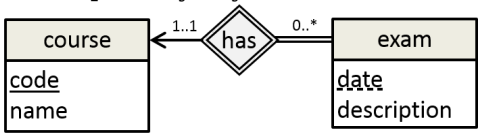
23 Choose the correct conversion of the E-R diagram to the relational model. Underlined attributes denote primary keys. Attributes with dotted underlining denote partial keys.



A course(code, name), exam(date, description);
B course(code, name), exam(date, description);
C course(code, name), exam(date, description), has(code,date);
***D** course(code, name), exam(code, date, description);
E course(code, name, date), exam(date, description);

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24 Assume a relational database containing two relations: *employee(emp_id, name, salary)* and *project(proj_id, emp_id, topic, len)*. The attribute *project.emp_id* is a foreign key to the relation *employee*. Suppose that both the relations have thousands of records and each attribute has a separate index.
Which one of the following relational algebra expressions is the most efficient transformation of the SQL command:

SELECT salary * len FROM employee NATURAL INNER JOIN project WHERE name = 'Joe' AND topic = 'X';

A $\pi_{salary*len}(\sigma_{name='Joe'}(employee \bowtie \sigma_{topic='X'}(project)))$

B $\pi_{salary*len}(\sigma_{name='Joe'}(\sigma_{topic='X'}(project \bowtie employee))$

C $\pi_{salary*len}(\sigma_{topic='X'}(\sigma_{name='Joe'}(employee) \bowtie project))$

***D** $\pi_{salary*len}(\sigma_{name='Joe'}(employee) \bowtie \sigma_{topic='X'}(project))$

E $\pi_{salary*len}(\sigma_{name='Joe' \wedge topic='X'}(project \bowtie employee))$

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25 A relation is in the Boyce-Codd normal form (BCNF) if

***A** the left side of each non-trivial functional dependency is a super key.
B all attributes that are part of any foreign key, are atomic.
C all attributes are atomic, independent, consistent, and durable.
D each attribute that is not dependent on a super key, is part of a candidate key.
E all attributes are atomic and the relation is in the third normal form (3NF).

Software Engineering

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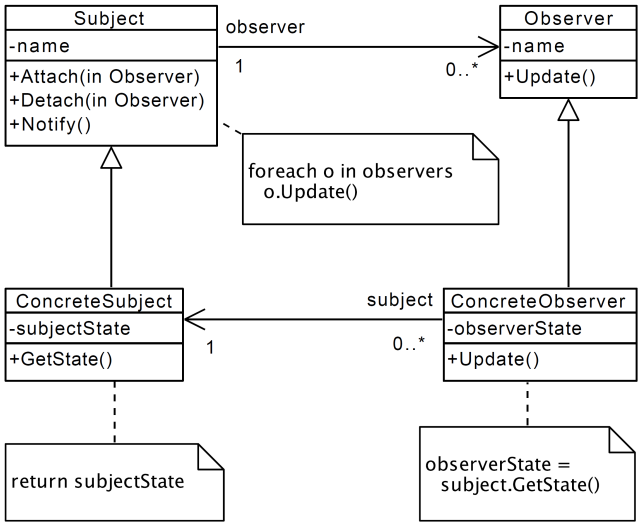
26 Consider the model depicted with the UML class diagram in the figure. Which one of the following statements is in correspondence with the model?



***A** An instance of the ConcreteSubject class might have a reference to zero or more instances of the Observer class.
B Each instance of the Subject class has a reference to exactly one instance of the Observer class.
C An instance of the ConcreteObserver class might have a reference to zero or more instances of the ConcreteSubject class.
D Each instance of the Observer class has a reference to exactly one instance of the Subject class.
E An instance of the ConcreteSubject class cannot have a reference to any instance of any other class.

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27 Which one of the following descriptions best characterizes Service Oriented Architecture (SOA)?

A SOA is an application architectural style, used for customer-service systems.
B SOA is an approach that defines process steps of service operations in the system (during system maintenance).
C SOA is an approach that defines steps within the customer-service process.
***D** SOA is an architectural style that suggests to compose complex systems out of autonomous components providing services to others.
E SOA is an architectural style that suggests to compose complex systems out of clearly delimited layers, containing interrelated services.

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28 Which one of the UML diagrams would you choose for modeling an interaction of objects in the system as the most suitable one?

A Entity-relationship diagram
B Data-flow diagram
***C** Sequence diagram
D Class diagram
E Parallel diagram

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29 Which one of the following techniques is **not** a software testing technique?

A Acceptance testing
B Beta testing
C Regression testing
***D** Whale testing
E Unit testing

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30 Which of the following statements characterize the benefits of software metrics in software development?
I. Facilitate software project management.
II. Facilitate the identification of progress in software development.
III. Facilitate the management of risks connected to software development.
IV. Facilitate the assessment of software product quality.
Choose the correct option:

***A** All I., II., III., IV.
B Only I. and III., not II. and IV.
C Only II. and IV., not I. and III.
D Only III. and IV., not I. and II.
E Only I., II. and III., not IV.
