

FI - Entrance exam - Computer Science

Name and Surname - fill in the field	Application No.	Test Sheet No.
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The computer science test consists of 30 questions, where you choose one of the possible answers a, b, c, d, e. Just one answer is correct. Each correctly answered question is valued by one point, an incorrectly answered question is valued -0.25. You get zero points for multiple selected answers or no answer. The test is divided into six pages and you cannot go back to the submitted pages.

Algorithms and Data Structures

1 Consider a minimum binary heap with integer keys implemented as an array. We first insert the following keys in the given order: 2, 8, 12, 1, 5, 7, 9 and then extract the minimum **twice**. What does the array contain at the end?

- A [1, 2, 5, 7, 8]
- *B [5, 8, 7, 12, 9]
- C [5, 7, 8, 9, 12]
- D [8, 5, 7, 1, 2]
- E [8, 7, 5, 2, 1]

2 Which statement is true?

- *A The functions $n \log n + 3n$ and $\log(2n!)$ have the same asymptotic growth.
- B There exists an $\mathcal{O}(\log n)$ algorithm that creates a binary heap from an unsorted array of elements.
- C The worst-case time complexity of inserting an element into a hash table with linear probing is in $\mathcal{O}(1)$.
- D We say that an algorithm is partially correct if it produces a correct output for at least half of the inputs.
- E B+ trees are a special case of binary search trees.

3 Which of the following is always true for every binary search tree (BST)?

- A The minimum key is stored in one of the leaves.
- B The depth of the tree is at most ten times the logarithm of the number of all nodes.
- *C The node with the minimum key does not have a left child.
- D Every node either contains exactly two children, or contains no children (i.e. is a leaf).
- E The median key is stored in the root.

4 Let $f(n) \in \mathcal{O}(n^2)$ and $g(n) \in \mathcal{O}(n \log n)$. Which statement is necessarily true?

- A $g(n)/f(n) \in \mathcal{O}(1)$
- B $g(n) \in \mathcal{O}(f(n))$
- *C $f(n) * g(n) \in \mathcal{O}(n^4)$
- D $f(n) \in \mathcal{O}(g(n))$
- E $f(n)/g(n) \in \mathcal{O}(1)$

- 5** Consider a directed graph. We run the 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 statement 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** None of the other statements is true in general.
 - D** If there is a path from vertex u to vertex v in the graph then $u.f > v.f$.
 - E** If there is a path from vertex u to vertex v in the graph then $u.f < v.f$.

Database Systems

- 6** Consider a registry of company car fleet that is implemented as a database with the relation $car(car_id, model, purchase_date)$. Assume that there is always just one car purchase for a date, i.e., the $purchase_date$ is unique.

Which query returns the identifier of the oldest car?

- *A** `SELECT car_id FROM car WHERE purchase_date IN (SELECT MIN(purchase_date) FROM car)`
- B** `SELECT car_id FROM car WHERE purchase_date IN (SELECT MIN(purchase_date) FROM car GROUP BY purchase_date)`
- C** `SELECT car_id FROM car WHERE purchase_date = MIN(purchase_date)`
- D** `SELECT car_id FROM car GROUP BY car_id HAVING purchase_date = MIN(purchase_date)`
- E** `SELECT car_id FROM car WHERE purchase_date IN (SELECT purchase_date FROM car ORDER BY purchase_date)`

- 7** Consider the relation $files(id, name, fileSize, created, data)$ and the following SQL expression:

`DELETE FROM files WHERE created < '2020-01-01' AND fileSize = 0`

Which relational algebra expression is equivalent to it?

- A** $files \leftarrow \sigma_{created \geq '2020-01-01' \wedge fileSize < > 0}(files)$
- B** $files \leftarrow \sigma_{created < '2020-01-01' \wedge fileSize = 0}(files)$
- *C** $files \leftarrow \sigma_{created \geq '2020-01-01'}(files) \cup \sigma_{fileSize < > 0}(files)$
- D** $files \leftarrow \sigma_{created \geq '2020-01-01'}(files) \cap \sigma_{fileSize < > 0}(files)$
- E** $files \leftarrow \sigma_{created < '2020-01-01'}(files) \cap \sigma_{fileSize = 0}(files)$

- 8** Transform the following E-R diagram to the relational model



Choose the answer that specifies the exact relations that the resulting relational model should have. Primary keys are underlined.

- A** $book(\underline{book_id}, name), author(\underline{author_id}, surname), written_by(\underline{book_id}, \underline{author_id})$
- *B** $book(\underline{book_id}, name), author(\underline{author_id}, surname), written_by(\underline{book_id}, \underline{author_id})$
- C** $book(\underline{book_id}, name), author(\underline{author_id}, surname)$
- D** $book(\underline{book_id}, name), author(\underline{author_id}, surname), written_by(\underline{book_id}, \underline{author_id})$
- E** $book(\underline{book_id}, name), author(\underline{author_id}, surname), written_by(\underline{book_id}, \underline{author_id})$

- 9** In parallel transaction processing, consider the database transactions T_1 and T_2 . In which case an instruction I_1 from T_1 is in conflict with an instruction I_2 from T_2 ?
- A The instructions I_1 and I_2 can never be in conflict, since they are from different transactions.
 - B If I_1 is reading and I_2 is writing a value from/to different rows (tuples) or vic versa.
 - C If both I_1 and I_2 are reading a value from different rows (tuples).
 - *D If I_1 is reading and I_2 is writing a value from/to the same row (tuple) or vice versa.
 - E If both I_1 and I_2 are reading a value from the same row (tuple).

- 10** Let us have a relation *rental*(*customer_id*, *rented_from*, *rented_to*, *car_id*, *price_per_day*) and the following set of functional dependencies:
customer_id, *rented_from* \rightarrow *rented_to*, *car_id*
car_id \rightarrow *price_per_day*
 We know that all attributes in *rental* are atomic.
 Which statement is true?
- A The relation is in the first normal form (1NF) but not in the second normal form (2NF).
 - B The relation is in the third normal form (3NF) but not in the fourth normal form (4NF).
 - C The relation is in the Boyce-Codd normal form (BCNF) but not in the third normal form (3NF).
 - *D The relation is in the second normal form (2NF) but not in the third normal form (3NF).
 - E The relation is in the third normal form (3NF) but not in the Boyce-Codd normal form (BCNF).

Computer Networks

- 11** How many IP addresses are defined by a class A network (mask 255.0.0.0)?
- A 65 534, i.e., $2^{16}-2$
 - *B 16 777 214, i.e., $2^{24}-2$
 - C 254, i.e., 2^8-2
 - D Not possible to enumerate because it is a range of multicast addresses.
 - E Not possible to enumerate because it is a reserved space, which is not used yet.
- 12** An electromagnetic signal sent from Brno by a cable (approx. 294 km long) will be received in Prague in the order of
- A picoseconds.
 - B seconds.
 - C nanoseconds.
 - *D milliseconds.
 - E microseconds.
- 13** Self-correcting codes used within data transfer allow the receiver:
- A to inform the sender only of errors incurred during the data transfer.
 - B to detect and repair all errors incurred during the data transfer.
 - C to inform the sender of errors incurred during the data transfer and to ask for the resubmission of wrongly received data.
 - D to detect all and repair almost all errors incurred during the data transfer.
 - *E to detect and repair almost all errors incurred during the data transfer.

- 14** A network (communication) protocol controls communication between two or more HW/SW components of a computer network and defines:
- A Structure (format) of sent messages and the necessary bandwidth.
 - B Authentication and reservation of communication resources.
 - C Authentication and sequence of messages.
 - *D Structure (format) of sent messages, sequence of messages, and the semantics of each part of the sequence.
 - E Authentication and authorization of a message.

- 15** Data transfer by UDP protocol is realized by:
- A An application forwards data blocks, UDP adds a header to each block, and assigns each block a sequential number starting from a random number.
 - *B An application forwards data blocks, UDP adds a header to each block, and forwards the blocks to the network protocol.
 - C An application forwards a stream of bytes, UDP cuts it into segments, and assigns each segment a positional number of the first byte of the block plus the randomly chosen sequence start.
 - D An application forwards data blocks, UDP adds a header to each block, assigns each block a sequential number starting from zero, and forwards the blocks to the network protocol.
 - E An application forwards a stream of bytes, UDP cuts it into segments, assigns each segment a sequential number starting from zero, and forwards the segments to the network protocol.

Computer systems

- 16** Consider a 4-way associative L1 cache memory. The CPU uses 32-bit physical address. The most significant 21 bits of this address serve as a tag, the next 7 bits serve for accessing one memory row, and the least significant 4 bits address one byte in a cache memory block. What is the L1 cache memory capacity in kibibytes (1024 bytes)?
- A 32 KiB
 - B 16 KiB
 - C 4 KiB
 - D 2 KiB
 - *E 8 KiB

- 17** Consider processes P_1 , P_2 , P_3 , and P_4 . Their arrival time and duration are specified in the following table.

Process	Arrival time	Duration
P_1	0,0 s	7 s
P_2	2,0 s	4 s
P_3	4,0 s	1 s
P_4	5,0 s	4 s

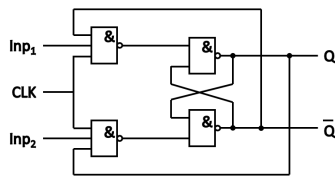
What is the average waiting time when we use the non-preemptive Shortest Job First scheduling algorithm?

- A 3 s
- B 5 s
- C 2 s
- D 7 s
- *E 4 s

18 Consider a one-bit full adder with inputs A, B, C_{in} , and outputs S, C_{out} . The inputs A and B are operands, C_{in} is an input carry, the output S is a sum of input values, and C_{out} is an output carry. The value on the C_{out} output can be expressed in Boolean algebra as:

- A $C_{out} = A + B + C_{in}$
- B $C_{out} = A \cdot B + C_{in}$
- C $C_{out} = A \cdot C_{in} + B \cdot C_{in}$
- *D $C_{out} = A \cdot B + A \cdot C_{in} + B \cdot C_{in}$
- E $C_{out} = A + B + A \cdot B \cdot C_{in}$

19 Consider the logic circuit given below.



This circuit serves as:

- A Dual-edge-triggered D flip-flop
- *B JK flip-flop
- C SR flip-flop
- D Master-slave JK flip-flop
- E Gated SR latch

20 Consider 58 to be a decimal number which is stored in an 8-bit register in two's complement representation. What number will be in this register after performing the following four operations?

1. Left 1-bit rotation (circular shift)
2. Bitwise NOT
3. Right 1-bit arithmetic shift
4. Right 1-bit rotation (circular shift)

- A -118
- B None of these numbers
- C -94
- *D -30
- E -29

Programming

21 Let us consider the following function:

```
function fun(unsigned integer n)
begin
    result = 1
    while n != 0
        n = n - 1
        result = result + 2 * n + 1
    end while
    return result
end
```

Assume that $n > 0$. What is the result computed by fun?

- A result = $2n$
- B result = 2^n
- *C result = $n^2 + 1$
- D result = n^2
- E result = $n^2 + 2n + 3$

22 Let us consider the following program. The print instruction outputs the given number without any end-of-line character.

```
function foo(integer n)
begin
    if n > 0 then
        foo(n-1)
        print n
        foo(n-2)
    end if
end
```

```
program main()
begin
    foo(4)
end
```

What is going to be printed by the program?

- A 342231
- B The program will run forever and never halt.
- *C 1231412
- D 1234
- E 342

23 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 all the true statements and none of the false ones.

I. Local variables of functions are always allocated on the heap.

II. Function calls are implemented using the queue.

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

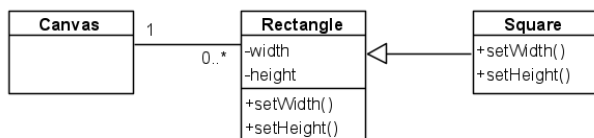
- A I, II, III
- B II, III
- C I, III
- *D III
- E I, II

- 24** Which statement is generally true in common OOP languages such as C++, Java, C#?
- A** The difference between static and non-static methods (member functions) is that static methods may access the static attributes (member variables) of a class.
 - *B** If early binding (non-virtual method calls) is used, the actual method to be called is decided at compile time.
 - C** The notions "class" and "object" mean the same thing.
 - D** If class B inherits from class A (via public inheritance), the instances of B can access all attributes (member variables) of A.
 - E** If class B inherits from class A (via public inheritance), every instance of A is considered to be an instance of B.
-

- 25** Which statement is **false**?
- A** A tail-recursive function can always be rewritten in an iterative manner.
 - B** A recursive function can always be rewritten in an iterative manner.
 - C** In purely functional languages, functions can have no side effects.
 - *D** When using call-by-value, the change of a parameter value inside of a function can be observed from the outside of the function.
 - E** The normal evaluation strategy in functional programming allows working with infinite data structures.
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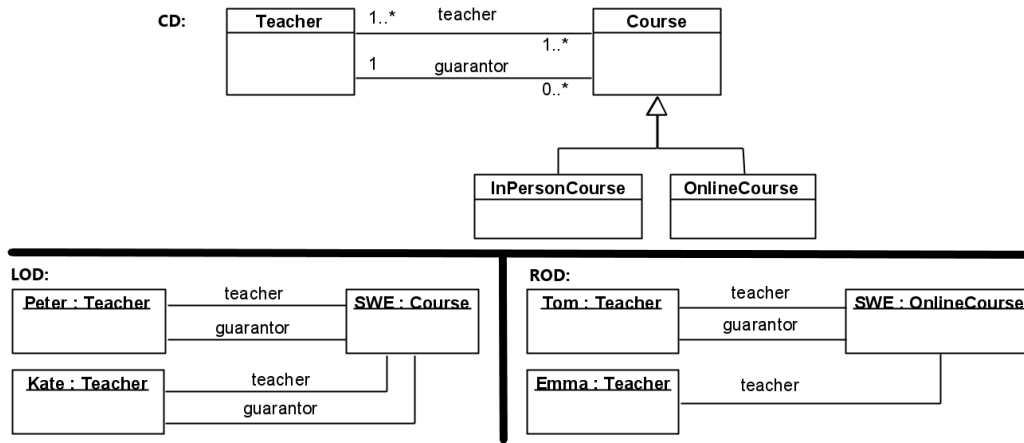
Software engineering

- 26** Which of the S.O.L.I.D. principles of clean code is violated by the example in the figure? Choose the one for which you see the most serious violation.



- A** Single-responsibility Principle
 - B** Interface Segregation Principle
 - *C** Liskov Substitution Principle
 - D** Open-closed Principle
 - E** Dependency Inversion Principle
-

27 Consider three UML models in the figure, i.e., the Class Diagram (denoted as CD), left Object Diagram (denoted as LOD), and right Object Diagram (denoted as ROD). Which of the following statements about these models is true?

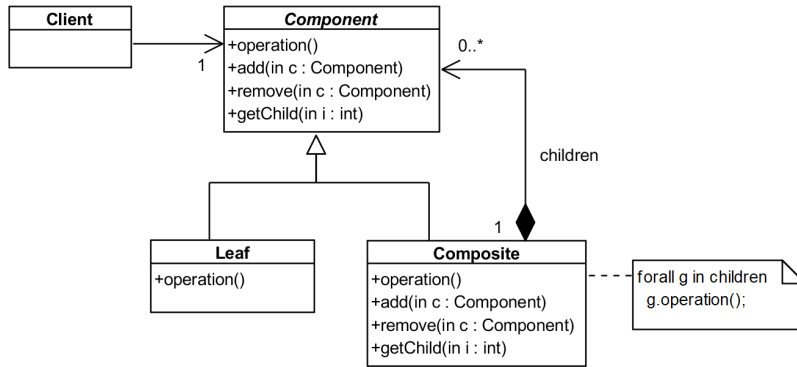


- A LOD is an instance of CD. ROD is an instance of CD.
- B LOD is not an instance of CD because there is no `InPersonCourse` nor `OnlineCourse` instance in LOD. ROD is an instance of CD.
- C LOD is not an instance of CD because there is no `InPersonCourse` nor `OnlineCourse` instance in LOD. ROD is not an instance of CD because Tom and Emma cannot be linked to an instance of `OnlineCourse` directly.
- *D LOD is not an instance of CD because there are two guarantors instead of one in LOD. ROD is an instance of CD.
- E LOD is an instance of CD. ROD is not an instance of CD because Tom and Emma cannot be linked to an instance of `OnlineCourse` directly.

28 Which requirement is a non-functional requirement?

- A After clicking on the "Search" link, the color of the link will change from blue to red.
- *B After clicking on the "Search" link, the search results page will be displayed within 1 second.
- C After clicking on the "Search" link, the search results page will be displayed.
- D After clicking on the "Search" link, information about the destination page of the link will be displayed in the "mouse over" dialog.
- E After clicking on the "Search" link, the search results page will be displayed without error messages.

29 Consider the UML model in the figure - a class diagram with one abstract class depicted in italics. Which statement describes a software-design-related problem in the model?



- A Instead of the association Composite->Component, there should be a reflexive association Component->Component.
- B The Client class shall have associations pointing to the Composite and Leaf classes directly.
- C An instance of the Composite class might only have references to instances of the Leaf class.
- *D The Leaf class supports operations such as add(), remove() and getChild(), although it cannot have any children.
- E The fact that the Component class is abstract makes it impossible for the Client to reference to any instance at all.

30 Which statement about software requirements is true?

- A Security is always more important than performance.
- B Performance is always more important than security.
- *C Poor requirements specification is the major reason why software projects fail.
- D Poor performance is the major reason why software projects fail.
- E There is no technique that would improve both reliability and security at the same time.

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