

Číslo zadání	Předmět / Odpovědník	Jméno a příjmení / učo
6	FI - Entrance exam - Computer Science	

The computer science test consists of 30 questions, where you choose one of the possible answers A, B, C, D, or 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.

## Algorithms and data structures

1. Consider the following sequences of expressions, where each expression denotes a function of one natural argument  $n$ . Which sequence orders the functions by their asymptotic growth (from the slowest growing to the fastest growing)?

- (A)  $\log(n!)$ ,  $n * (n - 100)$ ,  $n + \text{sqrt}(n)$   
 (B)  $\log(n!)$ ,  $n + \text{sqrt}(n)$ ,  $n * (n - 100)$   
 (C)  $n + \text{sqrt}(n)$ ,  $\log(n!)$ ,  $n * (n - 100)$   
 (D)  $n + \text{sqrt}(n)$ ,  $n * (n - 100)$ ,  $\log(n!)$   
 (E)  $n * (n - 100)$ ,  $\log(n!)$ ,  $n + \text{sqrt}(n)$

2. Consider a binary search tree without rebalancing and with unique keys. The tree is initially empty. We insert the following keys in the given order: 2, 8, 12, 1, 5, 7, 9, 4, 3, 11 and then remove the following keys in the given order: 2, 5, 1, 7. What is the **inorder** of the resulting tree?

- (A) [4, 11, 9, 12, 8, 3]  
 (B) [3, 4, 8, 9, 11, 12]  
 (C) [3, 8, 4, 12, 9, 11]  
 (D) [8, 4, 3, 12, 9, 11]  
 (E) [3, 4, 11, 9, 12, 8]

3. Which of the following is always true for maximum binary heap?
- (A) The median key is stored in one of the leaves.  
 (B) The median key is stored in the root.  
 (C) Every node either contains exactly two children, or contains no children (i.e., is a leaf).  
 (D) The maximum key is stored in one of the leaves.  
 (E) The maximum key is stored in the root.

4. Which statement about shortest-paths algorithms is true?
- (A) None of the other statements is true.  
 (B) Dijkstra's algorithm can be implemented either with a queue or a stack. The choice doesn't change the asymptotic time complexity of the algorithm, but the queue implementation is usually faster.  
 (C) If the graph contains no negative cycles, Dijkstra's algorithm always terminates and returns the correct shortest paths from a single source vertex to all the other vertices despite negative edges in the graph.  
 (D) The depth-first search (DFS) algorithm can be seen as a shortest-paths algorithm if all the edges have the same positive weight.  
 (E) If the given graph contains no negative cycles, Bellman and Ford's algorithm always terminates and returns the correct shortest paths between all pairs of vertices.

5. Which one of these statements is true?
- \***(A)** The complexity of the depth-first search (DFS) algorithm on trees is linear with respect to the number of vertices and edges; it doesn't matter whether we are given a tree or an arbitrary graph.
  - (B)** B-trees are a special case of binary search trees.
  - (C)** The worst-case time complexity of deleting an element from a hash table with quadratic probing is in  $O(1)$ .
  - (D)** The worst-case time complexity of deleting an element from a hash table with linear probing is in  $O(1)$ .
  - (E)** We say that an algorithm is partially correct if it produces a correct output at least for some of the inputs.
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## Programming

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6. Which statement is generally true in common OOP languages such as C++, Java, C#?
- (A)** If two or more classes inherit from the same base class, the runtime gets considerably slower, because all method calls have to check all the child classes for an implementation.
  - (B)** The difference between a class and an object is that objects can inherit from classes but not the other way round.
  - (C)** If a method of a class is declared as private, it means that it can access private attributes of that class; non-private methods cannot access those.
  - \***(D)** If late binding (virtual method calls) is used, the actual method to be called is decided at run time.
  - (E)** If class A inherits from class B (via public inheritance), every instance of B is considered to be an instance of A.
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7. On common platforms, every running program has two kinds of memory available, called the **stack** and the **heap**. Which of the following three statements I, II, and III are generally true?

Choose the option that contains all the true statements and none of the false ones.

- I. The stack is used to implement function calls.
- II. Accessing an object on the heap is logarithmic in the size of the heap.
- III. Accessing an object on the stack is linear in the size of the stack.

- (A)** II, III
  - (B)** I, II, III
  - (C)** I, III
  - (D)** I, II
  - \***(E)** I
- 

8. Let us consider the following function:

```
function fun(unsigned integer n)
begin
    result = 0
    while n != 0
        digit = XXX
        result = result + digit
        n = YYY
    end while
    return result
end
```

We want the function to compute the sum of the values of all the digits in the octal representation of  $n$ . The input  $n$  as well as the output is in decimal representation. What should we write instead of XXX and YYY? (Assume that `div` is the integer division operator and `mod` is the modulo operator.)

- (A)**  $XXX = n \bmod 8$ ;  $YYY = n \text{ div } 10$
  - \***(B)**  $XXX = n \bmod 8$ ;  $YYY = n \text{ div } 8$
  - (C)**  $XXX = \text{digit} + 1$ ;  $YYY = n - 8$
  - (D)**  $XXX = n \bmod 10$ ;  $YYY = n \text{ div } 8$
  - (E)**  $XXX = n \bmod 10$ ;  $YYY = n \text{ div } 10$
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9. Which statement is **false**?
- (A) When using call-by-value, any change of a parameter value inside a function cannot be observed from the outside of the function.
  - (B) In purely functional languages, functions can have no side effects.
  - (C) A primitive recursive function can always be rewritten in an iterative manner.
  - (D) A tail-recursive function can always be rewritten in an iterative manner.
  - \* (E) Some functions, such as the Ackermann function, can only be written using recursion; they cannot be rewritten in an iterative manner.
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10. Let us consider the following program. The print instruction outputs the given number without an end-of-line character.

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

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

What is going to be printed by the program?

- (A) 4321
  - (B) The program will run forever and never halt.
  - \* (C) 1213124
  - (D) 123124
  - (E) 1234
- 

## Computer Networks

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11. Which option contains a valid IPv4 host address in the correct format?
- (A) 192.168.253.0.1
  - (B) 0.0.0.0
  - \* (C) 172.17.1.11
  - (D) 224...1
  - (E) 192.168.256.53
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12. Computer networks interoperate thanks to extensive standardization. Which statement is correct?
- (A) NAT64 extends the existing time synchronization via NTP (Network Time Protocol) with 64-bit timestamps, so allowing to represent time after the year 2038.
  - \* (B) DNSSEC server can serve plain DNS clients transparently (plain DNS compatibility).
  - (C) IPv6 provides automatic routing, so static routes cannot be configured.
  - (D) Carrier-grade NAT maps IPv4 address space to the IPv6 address range 64:ff9b::/96
  - (E) The IP address ranges are allocated to a country by a company appointed by the local government.
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13. Which claim about media access control is **false**?
- (A) CSMA/CA is based on explicit acknowledges of delivered frames.
  - (B) CSMA/CD is used in wired ethernet, and CSMA/CA is used in wireless links.
  - (C) ALOHA prevents collisions.
  - \* (D) Contrary to CSMA/CA, CSMA/CD prevents eavesdropping.
  - (E) Media access control is not required in point-to-point links with separated media for each communication direction.
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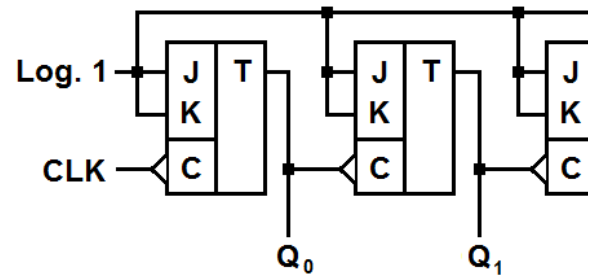
14. Which option contains only protocols without any cryptographic element (HMAC or encryption):
- \* (A) HTTP/1.0, ECHO, SMTP
  - (B) IPSec ESP, TCP, TELNET
  - (C) DNSSEC, UDP, IPX, SFTP
  - (D) HTTPS, FTP, IMAP
  - (E) IKEv1, EAP-TLS, POP3
-

15. Select the correct statement:
- (A) TCP server connects to a new TCP client because each TCP client waits for incoming connections and accepts them to establish a communication channel.
  - (B) TCP client actively joins an incoming connection initiated by the TCP server.
  - (C) TCP client connects to the TCP server, whereas the UDP server connects to the UDP client.
  - \* (D) UDP client actively sends a packet to the UDP server, where the UDP server must listen for incoming packets.
  - (E) TCP server ports are always negotiated before the TCP handshake, e.g. using an APR-1 protocol.

## Computer systems

16. Which of these standards **cannot** be used to connect a peripheral device?
- (A) USB - Universal Serial Bus
  - (B) Firewire (IEEE 1394)
  - \* (C) DMI - Direct Media Interface
  - (D) eSATA - external SATA
  - (E) Bluetooth
17. Which binary number is equivalent to the decimal number 19.375?
- (A) 11001.0111
  - (B) 1001.0111
  - \* (C) 10011.011
  - (D) 10101.0101
  - (E) 10011.101

18. Consider the following logic circuit controlled by falling (negative) edge.



Assume:

- a rectangular clock signal with frequency 10 Hz and duty cycle of 50 % is applied to the CLK input for one second,
- the outputs  $Q_0$ ,  $Q_1$ ,  $Q_2$ , and  $Q_3$  are initially set to logical low,
- the CLK signal starts at its zero level at time 0.0 seconds, and
- logical one is always on the inputs JK.

What is the decimal representation of binary values on the outputs  $Q_0$ ,  $Q_1$ ,  $Q_2$ , and  $Q_3$  in 532 ms?

Note:  $Q_3$  indicates the highest order and  $Q_0$  the lowest order.

- (A) 4
- (B) 10
- \* (C) 5
- (D) 7
- (E) 6

19. Select a true statement about interrupts in computer systems:
- (A) No interrupt can be masked.
  - (B) Interrupts can be triggered symmetrically or asymmetrically.
  - \* (C) An interrupt can be triggered also by a special instruction.
  - (D) Interrupts are always non-deterministic.
  - (E) In modern operating systems, each process creates its own interrupt table.

20. Which operation in Boolean algebra is equivalent to the Sheffer stroke and can be used to implement all other Boolean operators?

- (A) conjunction
- \* (B) negation of the conjunction
- (C) exclusive disjunction
- (D) negation of the exclusive disjunction
- (E) disjunction

## Database systems

21. Let the following functional dependency be defined for relation  $r(A, B, C, D)$ :

$$AB \rightarrow CD$$

Which option is always true?

- (A) If only the value of attribute A is known, then the value of C is unambiguously known, but the value of D cannot be decided unambiguously.
- \* (B) If both the values of attributes A and B are known, then the values of C and D are unambiguously known.
- (C) If only the value of attribute A is known, then both the values of C and D are unambiguously known.
- (D) If both the values of attributes C and D are known, then either the value of A or the value of B is unambiguously known.
- (E) If only the value of attribute C is known, then both the values of A and B are unambiguously known.

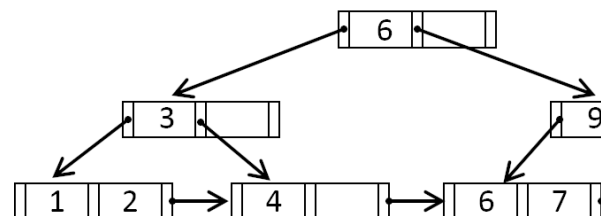
22. Consider the following relation in a CRM (customer relationship management) system:  $customer(custid, name, address, registration\_date)$ .

Which query returns the name of the oldest customer, i.e., the customer with the earliest registration date?

(Note: multiple customers can be returned if they registered on the same date).

- (A) `SELECT name FROM customer WHERE registration_date IN (SELECT MIN(registration_date) FROM customer GROUP BY registration_date)`
- \* (B) `SELECT name FROM customer WHERE registration_date = (SELECT MIN(registration_date) FROM customer)`
- (C) `SELECT name FROM customer WHERE registration_date=MIN(registration_date)`
- (D) `SELECT name FROM customer GROUP BY name WHERE registration_date < (SELECT MIN(registration_date) FROM customer)`
- (E) `SELECT name FROM customer GROUP BY name HAVING registration_date=MIN(registration_date)`

23. Consider the following instance of  $B^+$ -tree that represents an index on attribute  $id$  of a relation, where pointers to records are omitted for simplicity.



If the database needs to access a record with  $id = 3$ , the search algorithm traverses the tree and compares the requested value with keys in nodes.

What is the total number of comparisons made and the search outcome?

- \* (A) Three comparisons and the record is not found.
- (B) Two comparisons and the record is not found.
- (C) Three comparisons and the record is found.
- (D) Two comparisons and the record is found.
- (E) One comparison and the record is not found.

24. Choose the correct statement about the primary key (PK) of a relation:
- (A) PK can be any subset of the relation's attributes on which an index must be created.
  - \* (B) PK is a candidate key of the relation.
  - (C) PK contains the maximal number of dependent attributes of the relation.
  - (D) There can be several PKs for the relation.
  - (E) PK always contains at least two attributes of the relation.

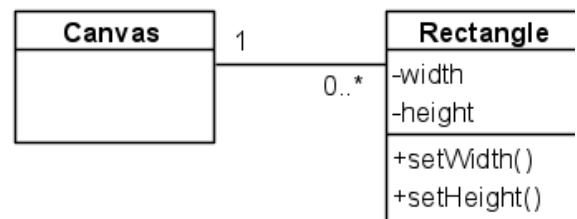
25. Consider relations `customer(custid, name, address)` and `account(accid, custid, balance)`. Let the attribute `account.custid` be a **not-null foreign key** that references the relation `customer`. Choose the **false** statement.
- (A) The relation `account` can be empty.
  - (B) If there is at least one tuple in the `account` relation, then the `customer` relation cannot be empty.
  - (C) The relation `customer` can be empty.
  - \* (D) If there is at least one tuple in the `customer` relation, then the `account` relation cannot be empty.
  - (E) If there are no tuples in the `customer` relation, then the `account` relation must be empty.

## Software engineering

26. Which of the following diagrams is best suited for modeling the life cycle of a single object or entity within the system, together with its reactions to events, triggering changes of the object/entity?
- (A) UML Class Diagram
  - (B) UML Use Case Diagram
  - (C) UML Object Diagram
  - \* (D) UML State (Machine) Diagram
  - (E) Entity-Relationship Diagram

27. As a software engineer, you lead the development of an information system for a start-up company that emphasizes price but does not yet have fully clarified system requirements. Do you prefer a waterfall or incremental development model and why?
- (A) I choose the waterfall model because it is a representative of agile methodologies that offer the means to rapidly develop systems with unclear requirements.
  - (B) I choose the waterfall model because it is the historical successor of the incremental model, which is no longer suitable to use today.
  - \* (C) I choose the incremental model because it will give the customer the opportunity to start using the first versions of the system soon, which will help clarify the requirements.
  - (D) I choose the incremental model because it is the historical successor of the waterfall model, which is no longer suitable for use today.
  - (E) I choose the waterfall model because it will lead to a lower development cost.

28. 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, where you may not expect to draw any other shape in the future.



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

- 29.** Consider the following statements about automated and manual testing.
- I. Regression testing is better to be performed with automated (rather than manual) testing.
  - II. For newly developed functionality, for which the final form has not yet been fully clarified, it is more appropriate to use manual testing.
  - III. Automated testing should be used to the maximum, as it always leads to higher system quality at a lower cost.
  - IV. It is better to perform performance and stress tests manually.

Which of these statements are generally true? Choose the option that contains all the true statements and none of the false ones.

- (A) II and IV.
  - (B) I, III and IV.
  - (C) I and II.
  - (D) I and III.
  - (E) II.
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- 30.** Which of the following descriptions best matches the mechanism of Exception Handling?
- \* (A) Detection, signaling and propagation of the information about system faults, including the handling on an appropriate place.
  - (B) Recording of a consistent state (either periodically or in response to specific events), to which the system can be restored.
  - (C) Redundant responding mechanism to events from multiple components in parallel. The response from only one component is used (usually the first to respond).
  - (D) Ability to perform a clean-up after a major failure, so that no disturbances remain in the system.
  - (E) System extension mechanism, which allows it to branch functionality beyond the planned functionality options.