

FI - Entrance exam - Computer Science

Jméno a příjmení - pište do okénka	Číslo přihlášky	Číslo zadání
		1

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. The test is divided into six pages and you cannot go back to the submitted pages.

Algorithms and data structures

- 1** Which of the following is always true for every binary search tree (BST)?
- A The maximum key is stored in the right-most leaf.
 - *B** None of the other statements is generally true.
 - C The median key is stored in the root.
 - D The depth of the tree is at most twice the logarithm of the number of all nodes.
 - E The median key is stored in one of the leaves.

- 2** Which statement about the depth-first search (DFS) algorithm is true?
- A None of the other statements is true.
 - B The algorithm only works for trees; other algorithms are needed for general graphs.
 - C The algorithm works in the same way as breadth-first search (BFS); the only difference is the usage of a stack instead of a queue.
 - D We can use the algorithm to enumerate all the cycles of a graph.
 - *E** The algorithm classifies the edges of the graph into four groups: tree edges, forward edges, back edges, and cross edges.

- 3** Let f be a function from naturals to positive reals defined as follows:
- $f(0) = 1,000,000$;
 - $f(n) = n^3$ for $0 < n < 100$;
 - $f(n) = 100n^2$ for $99 < n < 1,000$;
 - $f(n) = 1,000,000n$ for $n > 999$.

What is the smallest k such that $f(n) \in \mathcal{O}(n^k)$ but $f(n) \notin \mathcal{O}(n^{k-1})$?

- A 0
- *B** 1
- C 2
- D 3
- E 1.5

- 4** Which statement is true?
- A We say that an algorithm is partially correct if it produces a correct output for more than half of its inputs.
 - B Red-black trees are a special case of binary heaps.
 - C There exists an $O(n)$ algorithm that creates a binary search tree from an unsorted array of elements.
 - D The functions $n!$ and $(n + 1)!$ have the same asymptotic growth ("!" denotes the factorial).
 - *E** The worst-case time complexity of inserting an element into a hash table with quadratic probing is in $O(n)$.

- 5** Consider a minimum binary heap with integer keys implemented as an array. The heap is initially empty. We run the operations `Insert(2)`, `Insert(1)`, `Insert(8)`, `Insert(7)`, `ExtractMin()`, `Insert(1)`, `Insert(0)`, `ExtractMin()`. Which is the resulting content of the array?
- A [1, 2, 7, 8]
 - B [1, 7, 8, 2]
 - *C** [1, 2, 8, 7]
 - D [1, 7, 2, 8]
 - E [1, 8, 2, 7]

Programming

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

7 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. Arguments of functions are always allocated on the heap.
 II. Function calls are always implemented using a so-called trampoline.
 III. If an exception is caught (in a catch block), it can be re-thrown (using throw).

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

8 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-2)
        print n
        foo(n-1)
    end if
end
```

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

What is going to be printed by the program?

- A** 132243
***B** 2141321
C The program will run forever and never halt.
D 4321
E 243

9 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 $\text{fun}(n)$?

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

10 Which statement is generally true in common OOP languages such as C++, Java, C#?

- A** Static methods (member functions) are methods that prevalently access static attributes (member variables) of a class and rarely access non-static ones.
B If class B inherits from class A (via public inheritance), the instances of B can access any attribute (member variables) of A.
C If late binding (virtual method calls) is used, the actual method to be called is decided at compile time.
***D** Non-static methods (member functions) can access any attribute of the class, provided the access modifiers allow it.
E If class B inherits from class A (via public inheritance), every instance of A is considered to be an instance of B.

Computer Networks

11 Which option is a valid IPv4 broadcast address (not a station address)?

- A** 127.0.254.255/16
B 192.168.1.32/28
C 172.16.1.47/27
D 255.255.0.255/16
***E** 10.0.1.127/25

12 An IPv6 address is of

- A** 128 bits (16 Bytes) that are represented in the binary notation instead of the decimal one -- pairs of bytes are separated by a semi-colon ";".
***B** 128 bits (16 Bytes) that are represented in the hexadecimal notation instead of the decimal one -- pairs of bytes are separated by a colon ":". Various address abbreviation rules are defined, e.g., BDAC::0:1:FFFF is a correct address.
C 64 bits (8 Bytes) that are represented in the octal notation instead of the decimal one -- pairs of bytes are separated by a colon ":".
D 128 bits (16 Bytes) that are represented in the decimal notation -- pairs of bytes are separated by a dot ".".
E 128 bits (16 Bytes) that are represented in the hexadecimal notation instead of the decimal one -- pairs of bytes are separated by a colon ":". An address can be abbreviated using two-colon notation as many times as necessary, e.g., FDEC::BBFF::0:FFFF is a correct address.

- 13** Computer networks interoperate due to extensive standardization. Which option is correct?
- A The IP address range allocated for Czechia is limited to c73c:4000::/99.
 - *B A DNSSEC server can serve plain DNS clients transparently (plain DNS compatibility).
 - C Carrier-grade NAT maps IPv4 address space to the IPv6 address range 64:ff9b::/96 (so-called the Well-Known Prefix).
 - D The IP address range allocated for Czechia is managed by the organization CZ.NIC.
 - E NAT64 extends existing time synchronization via NTP with 64-bit timestamps (thus allowing to represent the time after the year 2038).

- 14** TCP controls the amount of transferred data in such a way that:
- *A it protects the receiver from being congested (Flow Control) and protects the network from being congested (Congestion Control).
 - B the amount of data allowed to be sent to the network is equal to the sum of values of the receiver's window size and congestion window.
 - C it protects the shared medium from collisions (Mac Control) and protects the receiver from being congested (Flow Control).
 - D it protects the shared medium from collisions (Mac Control).
 - E the amount of data that can be sent to the network is limited by the larger value of the following two: the receiver window size and the congestion window size.

- 15** Which claim about media access control is **false**?
- *A CSMA/CD prevents eavesdropping, contrary to CSMA/CA.
 - B CSMA/CD is used in wired ethernet and CSMA/CA is used in wireless links.
 - C Media access control is not required in point-to-point links with separated media for each communication direction.
 - D Aloha addresses collisions and retransmissions.
 - E CSMA/CA may use explicit acknowledgments of delivered frames.

Computer systems

- 16** Which segment register is **not** integrated in Intel processors?
- A CS - Code Segment
 - B SS - Stack Segment
 - C ES - Extra Segment
 - *D PS - Process Segment
 - E DS - Data Segment
- 17** Which statement is **not** valid in Boolean algebra?
- A $a \cdot (b + c) = (a \cdot b) + (a \cdot c)$
 - B $\neg(a) \cdot \neg(b) = \neg(a + b)$
 - *C $\neg(a \cdot b) = a + b$
 - D $a + (a \cdot b) = a$
 - E $a + (b \cdot c) = (a + b) \cdot (a + c)$

- 18** Which hexadecimal number is equivalent to the octal number 6471?
- A C57
 - B 4BF
 - *C D39
 - D 8AC
 - E E4B

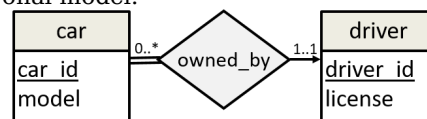
- 19** Operating (main) memories used in current computers are made as:
- *A Synchronous dynamic memories
 - B Non-volatile memories
 - C Associative memories
 - D Sequential memories
 - E Static memories

- 20** Inter-process synchronization and communication in modern operating systems is **not** based on:
- A shared memory
 - B a pipe
 - C a semaphore
 - D a mutex
 - *E a bridge

Database systems

- 21** Choose the **incorrect** description of an integrity constraint:
- *A CHECK constraint is used to restrict the values of the column, on which it is defined, only to values that are present in a primary key of another table.
 - B PRIMARY KEY constraint is a combination of the NOT NULL and UNIQUE constraints.
 - C UNIQUE constraint is used to restrict the values of the column, on which it is defined, so that no value other than NULL can be repeated.
 - D PRIMARY KEY constraint can be defined on multiple columns but there can be only one PRIMARY KEY constraint in a given table.
 - E NOT NULL constraint is used to restrict the values of the column, on which it is defined, so that a valid value must always be specified.

- 22** Transform the following E-R diagram to the relational model.



Select the answer that specifies the exact relations that the resulting relational model should have. Note that the primary keys are underlined.

- *A $car(\underline{car_id}, model, driver_id), driver(\underline{driver_id}, license)$
- B $car(\underline{car_id}, model), driver(\underline{driver_id}, license), owned_by(\underline{car_id}, \underline{driver_id})$
- C $car(\underline{car_id}, model), driver(\underline{driver_id}, license, \underline{car_id})$
- D $car(\underline{car_id}, model), driver(\underline{driver_id}, license)$
- E $car(\underline{car_id}, model), driver(\underline{driver_id}, license), owned_by(\underline{car_id}, \underline{driver_id})$

23 Consider a database for employees registry with relation `employee(emp_id, name, birth_date, super_id)`, where `birth_date` is unique, and `super_id` references `emp_id` of the direct superior employee.

Which SQL expression returns the name of the oldest direct subordinate of the employee with `emp_id = 1`?

- A `SELECT name FROM employee WHERE super_id = 1 ORDER BY birth_date DESC LIMIT 1;`
- B `SELECT name FROM employee WHERE emp_id = 1 AND birth_date = MIN(birth_date) GROUP BY super_id;`
- C `SELECT name FROM employee WHERE super_id = 1 AND birth_date = MIN(birth_date);`
- *D `SELECT name FROM employee WHERE birth_date IN (SELECT MIN(birth_date) FROM employee WHERE super_id = 1);`
- E `SELECT name FROM employee WHERE emp_id = 1 ORDER BY birth_date ASC LIMIT 1;`

24 Consider the relation `files(id, name, fileSize, created, data)`, where all the attributes are NOT NULL, and the following SQL command:

```
DELETE FROM files WHERE created < '2022-01-01' OR fileSize <= 0
```

Choose the relational algebra expression that does the exact same thing.

- A $files \leftarrow files - (\sigma_{created > '2022-01-01'}(files) \cap \sigma_{fileSize > 0}(files))$
- B $\sigma_{created < '2022-01-01'}(files) \cup \sigma_{fileSize \leq 0}(files)$
- C $files \leftarrow files \cup \sigma_{created < '2022-01-01'}(files) \cup \sigma_{fileSize \leq 0}(files)$
- *D $files \leftarrow \sigma_{created > '2022-01-01'}(files) \cap \sigma_{fileSize > 0}(files)$
- E $files \leftarrow \sigma_{created < '2022-01-01'}(files) \cup \sigma_{fileSize \leq 0}(files)$

25 Let us have a relation `tools(tool_id, name, rented_from, rented_to, emp_id)` of a tool rental company, and the following set of functional dependencies:

`tool_id → name`

`tool_id, rented_from → emp_id, rented_to`

We know that the relation already is in the first normal form (1NF).

Select the decomposition of the relation `tools` that satisfies the second normal form (2NF):

- *A `tools1(tool_id, name), tools2(tool_id, rented_from, rented_to, emp_id)`
- B `tools1(tool_id, rented_from), tools2(name, emp_id, rented_to)`
- C `tools1(tool_id, name, emp_id), tools2(emp_id, rented_from, rented_to)`
- D `tools1(tool_id, name), tools2(rented_from, rented_to, emp_id)`
- E `tools1(tool_id, name, emp_id), tools2(tool_id, rented_from, rented_to)`

Software engineering

26 Which UML diagram would you choose for modeling message exchange among objects in a developed system?

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

27 Consider the following examples of relationships in a UML class diagram. Which one of the following gives the best fitting examples of their proper usage?

- A Vehicle-Driver is a composition; Vehicle-Car is a general association; Car-Engine is an inheritance.
- B Vehicle-Driver is a composition; Vehicle-Car is an inheritance; Car-Engine is a general association.
- C Vehicle-Driver is a general association; Vehicle-Car is a composition; Car-Engine is an inheritance.
- D Vehicle-Driver is an inheritance; Vehicle-Car is a general association; Car-Engine is a composition.
- *E Vehicle-Driver is a general association; Vehicle-Car is an inheritance; Car-Engine is a composition.

28 Which of the following statements are true for *version control systems*? Choose the option that contains all the true statements and none of the false ones.

- I. Version control systems support the management of changes to documents, software programs, and other collections of information.
- II. Version control systems can run as stand-alone applications, but can also be embedded in various types of software such as IDEs.
- III. Version control systems allow for the ability to revert a document to a previous revision, which is important for allowing editors to track each other's edits and correct mistakes.
- IV. The three most commonly used commands of version control systems are import, export, and merge.

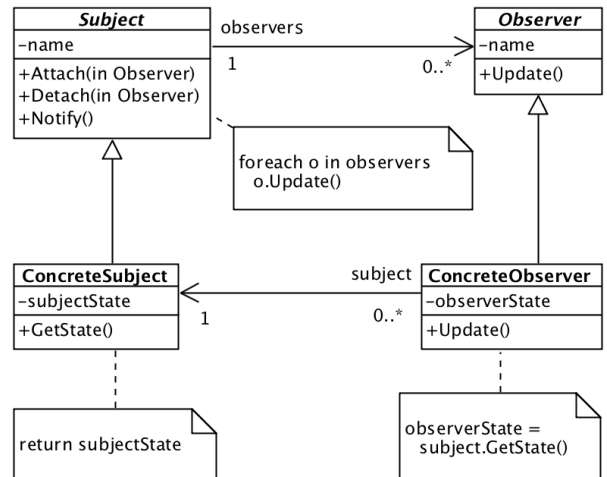
- A Only II. and III.
- B Only I., III., IV.
- C Only I. and III.
- *D Only I., II., III.
- E All I., II., III., IV.

29 Which of the following statements are true for *performance* as a quality attribute of information systems? Choose the option that contains all the true statements and none of the false ones.

- I. Performance is being primarily characterized by "availability", which is the degree to which a system is able to respond to requests at any point in time.
- II. Performance is being primarily characterized by "response time", which is the time that system needs to execute its computation and return a response.
- III. The properties of performance include "throughput" and "resource utilization".

- A Only II.
- B Only I. and III.
- *C Only II. and III.
- D All I., II. and III.
- E Only I.

30 Consider a model depicted with the UML class diagram in the figure. Which statement is in correspondence with the model?



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

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