Číslo zadání	Předmět / Odpovědník	Jméno a příjmení / učo
1	**FI - Přijímací zkouška: Test z informatiky (zahájení v 15:00)**	

The computer science test consists of 30 questions, where you choose one of the possible answers. Each question has just one correct answer. Each correctly answered question is valued by 1 point, an incorrectly answered question is valued -0.25. You get 0 points for no answer. Once you have submitted the test (by clicking the Submit button) and confirmed your submission, you will not be able to return to the test.

Algorithms and data structures

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

(A) $\log(2^n), \log(n^7), n\log(n)$
(B) $n\log(n), \log(2^n), \log(n^7)$
(C) $\log(2^n), n\log(n), \log(n^7)$
*(D) $\log(n^7), \log(2^n), n\log(n)$
(E) $\log(n^7), n\log(n), \log(2^n)$

2. Which of the following is true for **any** binary search tree?

(A) The median key is stored in one of the leaves.
(B) Every node either contains exactly two children or no children.
(C) The maximum key is stored in one of the leaves.
(D) The median key is stored in the root.
*(E) The node with the maximum key does not have the right child.

3. Which statement about graph algorithms and their time complexity is true?

(A) None of the other statements is true.
(B) The worst-case complexity of the depth-first search (DFS) algorithm is exponential with respect to the longest path of the graph.
(C) The complexity of Dijkstra's algorithm, when implemented using a binary heap and executed for a particular source vertex, is in $\mathcal{O}(E+V)$, where V is the number of vertices and E is the number of edges.
*(D) The complexity of Dijkstra's algorithm, when implemented using a binary heap and executed for a particular source vertex, is in $\mathcal{O}(E\log V)$, where V is the number of vertices and E is the number of edges.
(E) The worst-case complexity of the depth-first search (DFS) algorithm is exponential with respect to the shortest path of the graph.

4. Which statement is true?

(A) The invariant of a while cycle is the largest number of iterations that the cycle can have.
(B) The invariant of a while cycle is the condition written after the while keyword.
*(C) None of the other statements is true.
(D) The invariant of a while cycle is the last statement in the cycle.
(E) The invariant of a while cycle is the smallest number of iterations that the cycle can have.

5. Consider a red-black tree 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) [3, 4, 11, 9, 12, 8]
(B) [3, 8, 4, 12, 9, 11]
*(C) [3, 4, 8, 9, 11, 12]
(D) [8, 4, 3, 12, 9, 11]
(E) [4, 11, 9, 12, 8, 3]

Programming

6. 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 heap is used to implement function calls.
II. Local variables are usually allocated on the stack.
III. Dynamic allocation uses the heap.

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

7. 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 base-eleven representation of n. What should we substitute for XXX and YYY? (Assume that div is the integer division operator, mod is the modulo operator, and e is Euler's number.)

(A) XXX = n mod 10; YYY = n div 10
(B) XXX = n mod 100; YYY = n div 100
*(C) XXX = n mod 11; YYY = n div 11
(D) XXX = digit + 1; YYY = n - 11
(E) XXX = n mod e; YYY = n div e

8. Which statement is **false**?
*(A) The strict evaluation strategy in functional programming allows working with infinite lists (also known as streams).
(B) Any tail-recursive function can be rewritten in an iterative manner.
(C) Any primitive recursive function can be rewritten in an iterative manner.
(D) In purely functional languages, functions can be passed as arguments to other functions.
(E) When using call-by-value, the change of a parameter value inside a function cannot be observed from the outside of the function.

9. 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
                print n
                foo(n-1)
                foo(n-2)
        end if
end

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

What is going to be printed by the program?
(A) 432121321
(B) 1231412
(C) 2141321
(D) 1213124
*(E) 4321121

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10. Which statement is generally true in common OOP languages such as C++, Java, C#?
(A) If a method of a class is declared static, this means that the lifetime of its local variables is extended to the end of the whole program.
*(B) More than one class can be inherited from the same base class.
(C) If a method of a class is declared virtual, this means that the method does not really exist and is just a placeholder to be implemented later.
(D) If a method of a class is declared volatile, this means that it can change the state of the current object.
(E) If class B inherits from class A (via public inheritance), every instance of A is also considered to be an instance of B.

Computer Networks

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11. What is the MAC address `ff:ff:ff:ff:ff:ff` used for every day?
(A) It is a reserved wildcard address (similar to IPv4 address 0.0.0.0).
(B) It is an address-unspecified flag (-1 stored as a 56-bit integer).
*(C) It is an L2 broadcast address (used, e.g., in ARP "who-has" queries).
(D) It produces a deliberate checksum error in L2 protocols and propagates to higher layers.
(E) It is a reserved MAC address for testing purposes (like domain example.com).

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12. Which statement is correct?
(A) Gigabit L2 network using CAT 6A cabling can span up to 3km.
(B) Singlemode optical fiber transmits magnetic flux.
(C) Gigabit ethernet uses Unshielded Tripple Pair cabling (IEEE 802.11 1000BaseT).
*(D) RJ-11 (cable connector) provides 4 metal contacts, RJ-12 6 metal contacts and RJ-45 8 metal contacts.
(E) 2.4 GHz Wi-Fi uses water molecule resonance to boost signal levels during rain.

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13. Choose the correct protocol-layer pairing in ISO/OSI model:
*(A) SNMP - Application Layer, Manchester - Physical Layer, UDP - Transport Layer
(B) SSH - Application Layer, ARP - Link Layer, UDP - Transport Layer
(C) SSH - Application Layer, 4B/5B - Network Layer, UDP - Transport Layer
(D) TCP - Application Layer, 4B/5B - Network Layer, UDP - Transport Layer
(E) SNMP - Network Layer, NRZI - Transport Layer, TCP - Session Layer

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14. Which of the following provides an IPv6 link-local address **equivalent in IPv4**?
(A) Any private IP address (e.g., 192.168.1.1)
(B) Broadcast address on a given interface (e.g., 192.168.255.255)
*(C) Any address from the range 169.254.0.0/16 (e.g.,169.254.0.255)
(D) Any address from range 172.16.0.0/16 (e.g., 172.16.32.4)
(E) No link-local addressing exists for IPv4, multicast address 224.0.0.1 is used instead.

15. What does the acronym MPLS refer to in computer networking?
*(A) Multiprotocol Label Switching (routing mechanism)
(B) Multiple Path Lane Symmetry (logical interface bonding)
(C) Multiplane Link System (physical cable topology)
(D) Multiple Polarisation Laser System (long-range fiber ethernet)
(E) No such acronym is generally recognized.

Computer systems

16. Which of these x86 instructions **is not** arithmetic?
(A) ADC
(B) INC
(C) IMUL
(D) SUB
*(E) INT

17. Peterson's algorithm is typically used:
*(A) to solve the problem of mutual exclusion.
(B) to search for the victim frame when the physical memory is full (in virtual memory management).
(C) to plan the CPU.
(D) to solve the thrashing problem.
(E) to handle the page-fault interrupt.

18. Which of the following decimal numbers can be stored as a binary number in computer memory with absolute precision?
*(A) 0.5
(B) 0.3
(C) 0.1
(D) 0.4
(E) 0.2

19. The Translation Look-aside Buffer (TLB) is used:
(A) to store prefetched instructions.
*(B) to increase the efficiency of the paging process.
(C) to increase the efficiency of the segmentation process.
(D) as a storage of instructions that will be executed out of order.
(E) as an auxiliary memory to implement branch prediction.

20. The page-fault interrupt is triggered by:
(A) unsuccessful verification of the file permissions.
(B) each access to the virtual memory.
*(C) a reference to the address that is not present in the physical address space.
(D) a hardware fault of the memory chip.
(E) an I/O device communication fault.

Database systems

21. Consider a database with the following three relations: `employee(`<u>`emp_id`</u>`, name, salary)`, `project(`<u>`proj_id`</u>`, name)`, and `works_on(`<u>`emp_id`</u>`, `<u>`proj_id`</u>`, start_date)`. The attributes `emp_id` and `proj_id` in the relation `works_on` are foreign keys that reference the relations `employee` and `project`, respectively. Apart these foreign keys, there are just the underlined primary keys and no other constraints defined on the tables.

The E-R diagram, from which such a database was generated, would contain:
(A) Three entities "employee", "project" and "works_on". There will be three many-to-many relationships in the diagram: one between employee and project, one between employee and works_on, and one between project and works_on.
(B) Two entities "employee" and "project", and a relationship "works_on" with many-to-one cardinality (an employee can work on many projects, on a project can work one employee at most).
(C) Two entities "employee" and "project", and a relationship "works_on" with one-to-many cardinality (an employee can work on one project at most, on a project can work many employees).
*(D) Two entities "employee" and "project", and a relationship "works_on" with many-to-many cardinality.
(E) Three entities "employee", "project" and "works_on". There will be no relationships in the diagram.

22. Let us have the relation `tools(tool_id, name, rented_from, rented_to, emp_id)` and the following set of functional dependencies:

```
tool_id → name
tool_id, rented_from → emp_id, rented_
tool_id, rented_to → emp_id, rented_fr
```

We know that the relation is in the first normal form (1NF).
Select the decomposition of the relation `tools` that satisfies the Boyce-Codd normal form (BCNF):
*(A) `tools1(tool_id, name)`, `tools2(tool_id, rented_from, rented_to, emp_id)`
(B) `tools1(tool_id, name, emp_id)`, `tools2(tool_id, rented_from)`, `tools3(tool_id, rented_to)`
(C) `tools1(tool_id, name, emp_id)`, `tools2(tool_id, rented_from, rented_to)`
(D) There is no decomposition of the given relation that satisfies BCNF.
(E) `tools1(tool_id, name)`, `tools2(tool_id, rented_from, emp_id)`, `tools3(tool_id, rented_to, emp_id)`

23. Which statement is **false**?
(A) 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.
(B) PRIMARY KEY constraint can be defined on multiple columns but there can be only one PRIMARY KEY constraint in a given table.
(C) PRIMARY KEY constraint is a combination of the NOT NULL and UNIQUE constraints.
(D) UNIQUE constraint is used to restrict the values of the column, on which it is defined, so that no value can repeat.
*(E) 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.

24. Consider the following relation in a CRM (Customer Relationship Management) system: customer(<u>custid</u>, name, city, regdate) and the following relational algebra expression:

$$customer \leftarrow \sigma_{regdate >= '2024-01-01'}(customer)$$

Choose the SQL command that will do the exact same thing.

(A) DELETE FROM customer WHERE regdate >= '2024-01-01' AND city != 'Brno'

(B) DELETE FROM customer WHERE regdate < '2024-01-01' AND city = 'Brno'

*(C) DELETE FROM customer WHERE regdate < '2024-01-01' OR city != 'Brno'

(D) DELETE FROM customer WHERE regdate < '2024-01-01' AND city != 'Brno'

(E) DELETE FROM customer WHERE regdate >= '2024-01-01' OR city = 'Brno'

25. Consider an employee registry implemented as the relations: employee(<u>emp_id</u>, name, salary), project(<u>proj_id</u>, name), and works_on(<u>emp_id</u>, <u>proj_id</u>, start_date). The attributes emp_id and proj_id in the relation works_on are foreign keys that reference the relations employee and project, respectively. Assume that all three relations are not empty.

Which SQL query returns a list of names of every project along with the sum of the salaries of all the employees that work on that particular project?

Note: If there are no employees working on a project, the project name should also appear with an empty (NULL) sum of the salaries.

(A) SELECT project.name AS project, SUM(salary) AS salary
FROM project RIGHT JOIN works_on USING (proj_id) RIGHT JOIN employee USING (emp_id)
    GROUP BY project.name

(B) SELECT project.name AS project, SUM(salary) AS salary
FROM project, works_on, employee
    WHERE project.proj_id = works_on.proj_id AND employee.emp_id = works_on.emp_id
    GROUP BY project.name
UNION DISTINCT
    SELECT project.name AS project, 0 AS salary
    FROM project

*(C) SELECT project.name AS project, SUM(salary) AS salary
FROM project LEFT JOIN works_on USING (proj_id) LEFT JOIN employee USING (emp_id)
     GROUP BY project.proj_id, project.name

(D) SELECT project.name AS project, SUM(salary) AS salary
FROM project, works_on, employee
    GROUP BY project.proj_id, project.name

(E) SELECT project.name AS project, SUM(salary) AS salary
FROM project INNER JOIN works_on USING (proj_id) INNER JOIN employee USING (emp_id)
    GROUP BY project.name
 UNION ALL
    SELECT project.name AS project, 0 AS salary
    FROM project

Software engineering

26. How are Function Points (FP) used during the software development process?
*(A) FPs can help estimate project duration during effort estimation.
(B) FPs can help software developers fix software defects.
(C) FPs can help software developers trace the causes of software failures back to source code.
(D) FPs can help model the software calls from source code methods (fan-in / fan-out).
(E) FPs can help software developers estimate the system's throughput and identify performance bottlenecks.

27. What does the Cyclomatic Complexity (CC) metric represent?
(A) The complexity of maintaining a software module defined as $C(m) = \ln(V_m)\ln(LOC_m)$, where V_m is the code volume of the module m (the number of distinct operators and distinct operands), and LOC_m are the module's number of lines of code.
(B) The complexity of the coupling between classes, defined as $C(c) = \frac{n(n-1)}{2}$, where c is a class, and n is the number of calls that the class c has to other classes in the system.
(C) The complexity in terms of effort to produce a certain amount of source code, defined as $C(m) = (Size/Productivity * Time)$, where $Size$ the lines of code of the module m, $Productivity$ and $Time$ depend on the development team and project schedule, and b is a project scaling factor for the domain's complexity.
*(D) The number of decision points in a software program, defined as $C(CFG) = E - N + 2$, where E is the number of edges and N is the number of nodes in the Call Flow Graph (CFG) of a source code.
(E) The semantic complexity of writing a software program, defined as $C = VD$, where V is the code volume (the number of distinct operators and distinct operands), and D is an index about the level of complexity of the programming language (e.g., assembly will have higher complexity than Java).

28. Suppose a microservice system with only two different services implemented (A,B), each one as a single instance. You have some initial implementation, and your instance of service A returns the results based on the composition with service B, i.e., A → B. The two instances of services are independent in terms of failures.

The availability of service A (defined as av(A)=1-(downtime/(uptime+downtime))) is estimated as 99%, and the availability of service B is 90%. What is the estimated overall system's availability?

*(A) 89.1%
(B) 85.6%
(C) 99.0%
(D) 90.0%
(E) It cannot be determined based on the provided information.

29. Which type of testing is focused on verifying whether a software system meets the business requirements?

*(A) Acceptance testing
(B) Integration testing
(C) Unit testing
(D) End-to-end Testing
(E) System testing

30. Based on the UML notation representing the Visitor Design Pattern diagram in the figure, consider the following statements:
I. Element has a dependency on the Visitor class;
II. Element has an association with the Visitor class;
III. Each ConcreteVisitor class extends the Visitor abstract class;
IV. Each ConcreteVisitor class implements the Visitor interface;
V. ConcreteElementB can only accept instances of ConcreteVisitor2 classes in the accept() method;
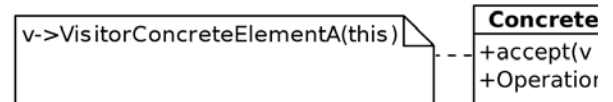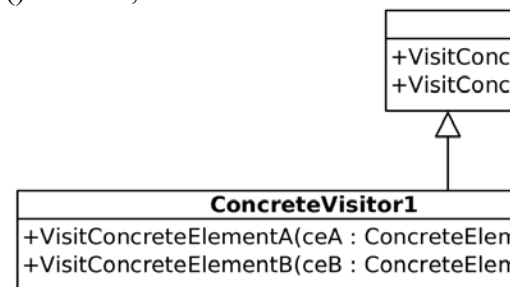
Choose the option that contains all the true statements and none of the false ones.

(A) I, IV.
(B) II, III, V.
(C) II, III.
*(D) I, III.
(E) II, IV.