

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 minimum key is stored in the left-most leaf.
- B The minimum key is stored in the right-most leaf.
- C The depth of the tree is at most ten times the logarithm of the number of all nodes.
- *D None of the other statements is true.
- E The minimum key is stored in the root.

2 Which statement is true?

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

3 Which statement about the depth-first search (DFS) algorithm is true?

- A All cycles in a graph can be listed by running the algorithm once.
- *B The algorithm classifies the edges of the graph into four groups: tree edges, forward edges, back edges, and cross edges.
- 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 None of the other statements is true.
- E The algorithm only works for trees; other algorithms are needed for general graphs.

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

- A $\frac{f(n)}{g(n)} \in \mathcal{O}(\log n)$
- B $\frac{g(n)}{f(n)} \in \mathcal{O}(\log n)$
- C $f(n) \in \mathcal{O}(g(n))$
- *D $f(n)g(n) \in \mathcal{O}(n\sqrt{n})$
- E $g(n) \in \mathcal{O}(f(n))$

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

Database systems

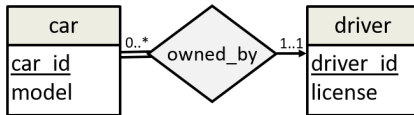
- 6** Choose the correct sequence of steps that a relational database performs when processing an SQL query (SELECT):
- *A syntactic and semantic check of the SQL query, translation of the SQL query to relational algebra, selection of the optimal execution plan for the relational algebra expression using statistics, evaluation of the selected plan on actual data, and transfer the results.
 - B start of a transaction, translation of the SQL query to the relational algebra, syntactic and semantic check of the relational algebra expression, optimization of the relational algebra expression using actual data, evaluation of the optimized expression on actual data, commit of the transaction, and transfer of the results.
 - C translation of the SQL query to relational algebra, syntactic and semantic check of the relational algebra expression, evaluation of the relational algebra on actual data, and transfer the results.
 - D syntactic and semantic check of the SQL query, optimization of the SQL query using the actual data, the start of a transaction, evaluation of the SQL query on actual data, commit of the transaction, and transfer the results.
 - E start of a transaction, translation of the SQL query to relational algebra, optimization of the relational algebra expression using statistics, evaluation of the optimized expression on actual data, transfer the results, and commit of the transaction.

- 7** Let us have a relation $book(book_id, name, rented_from, rented_to, student_id)$, where all its attributes are atomic.
Choose the correct statement if the following functional dependencies hold on the relation:
 $book_id \rightarrow name$
 $book_id, rented_from \rightarrow student_id, rented_to$
- A It is in the third normal form (3NF) but not in the Boyce-Codd normal form (BCNF).
 - B It is in the Boyce-Codd normal form (BCNF) but not in the third normal form (3NF).
 - C It is in the third normal form (3NF) but not in the fourth normal form (4NF).
 - D It is in the second normal form (2NF) but not in the third normal form (3NF).
 - *E It is in the first normal form (1NF) but not in the second normal form (2NF).

- 8** Consider the relation $files(id, name, fileSize, created, data)$ and the following relational algebra expression:
 $files \leftarrow \sigma_{created < '2022-01-01'}(files) \cap \sigma_{fileSize > 0}(files)$
- Choose the SQL expression that will do exactly the same thing.
- A UPDATE files WHERE created < '2022-01-01' INTERSECT fileSize > 0
 - B INSERT INTO files (SELECT * FROM files WHERE created >= '2022-01-01' OR fileSize <= 0)
 - C INSERT INTO files (SELECT * FROM files WHERE created < '2022-01-01' AND fileSize > 0)
 - D DELETE FROM files WHERE created < '2022-01-01' AND fileSize > 0
 - *E DELETE FROM files WHERE created >= '2022-01-01' OR fileSize <= 0

- 9** Consider a registry of company car fleet stored in the relation $car(car_id, model, purchase_date)$.
Which relational algebra expression returns the identifier (car_id) of the oldest car?
Assume that there is always only one car purchased on a given date, i.e., the $purchase_date$ is unique.
- A $\pi_{car_id}(\sigma_{purchase_date = \text{MIN}(purchase_date)}(car))$
 - B $\pi_{car_id}(\sigma_{purchase_date = \text{MIN}(purchase_date)}(car_id \mathcal{G}_{\text{MIN}(purchase_date)}(car)))$
 - *C $\pi_{car_id}(\rho_x(purchase_date)(\mathcal{G}_{\text{MIN}(purchase_date)}(car)) \bowtie car)$
 - D $\pi_{car_id}(\sigma_{purchase_date = \text{min_purchase_date}}(\rho_x(car_id, \text{min_purchase_date})(car_id \mathcal{G}_{\text{MIN}(purchase_date)}(car)) \bowtie car))$
 - E $\pi_{car_id}(\sigma_{purchase_date = \text{min_purchase_date}}(\rho_x(car_id, \text{min_purchase_date})(car_id \mathcal{G}_{\text{MIN}(purchase_date)}(car)) \times car))$

10 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. Note that the underlined attributes denote the primary key (if no attribute is underlined, the primary key is not defined).

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

Computer Networks

11 TCP also provides flow and congestion control. This is achieved through:

- A There is only one communication channel congested at a time, thus two separate channels are used. The control connection can reliably deliver a slow-down request to the sender even if the data connection is congested.
- *B A positive and negative acknowledgment mechanism is deployed. If the line is congested, the acknowledgment is not received, and thus, transmission since the last acknowledgment is repeated at a slower rate.
- C Both sides exchange a small synchronization packet (SYN). Only the party currently owning the packet can transmit.
- D Sender transmits and receives the transmission at the same time. If the received data do not match transmitted data, the transmission is repeated.

12 What network protocols will be used during a modification of routing tables of a border router when the update is performed remotely via a command-line interface by the router administrator in person?

- A SMTP, DNS, SSH, TCP, IPX, ARP
- *B DNS, SSH, TCP, IP, ARP, and eventually BGP
- C DNS, SSH, UDP, IP, ARPE and eventually ROUTE
- D HTTP, SSH, UDP, IP, ARP and eventually BGP

13 Contemporary computer networks work mainly thanks to extensive standardization. Which statement is correct?

- A NAT is a mechanism for guaranteed unique addressing on the internet.
- B The organizations responsible for IP allocations are CERN (Europe), DARPA (North America), and AKAMAI (Asia).
- C 6in4 is a specific format of IPv6 header designed to overlap with IPv4 header, so IPv6 traffic is transparently routed on IPv4-only networks (this is only available for certain IPv6 address ranges).
- *D Significant portion of standards are merely requests for comments.

14 Which statement does **not** hold for media access control?

- A CSMA/CA protocol assumes that the intended recipient can be jammed by a signal unknown to the sender.
- B CSMA/CD protocol is deployed for cable ethernet, while CSMA/CA is deployed in wireless ethernet (wifi).
- *C CSMA/CA protocol is deployed for cable ethernet, while CSMA/CD is deployed in wireless ethernet (wifi).
- D CSMA/CD protocol assumes that the signal received by the intended recipient can be at the same time frame received by the sender as well.

15 A router will receive two IPv4 packets that form one UDP datagram. The outgoing interface has an even smaller MTU than the receiving. Which statement corresponds to the standard behavior of the router?

- A Router awaits for the second packet, parses the UDP datagram, and refragments the datagram to the needed count of IPv4 packets.
- B Router immediately fragments each packet to the needed output packets, updates the payload offsets, and sets the UDP header only in the first packet on output.
- C Router immediately fragments each packet to the needed count of packets and any follow-up fragments are renumbered on output.
- *D Router immediately fragments each packet to the needed count of output packets, updates the payload offsets, and sets the UDP header in every packet created on output.

Computer systems

16 Consider a HDD interface which uses the following addressing mode:

- 16 bits are reserved for cylinder,
- 4 bits are reserved for head, and
- 8 bits are reserved for sector.

What is the maximum capacity of HDD that can be connected to this interface when one sector stores 512 B?

- A 1 TiB
- B 256 GiB
- *C 128 GiB
- D 512 GiB
- E 64 GiB

17 Consider the four processes P_1 , P_2 , P_3 , and P_4 that are queued for execution in the same order, and their durations:

Process	Duration
P_1	53 ms
P_2	17 ms
P_3	68 ms
P_4	24 ms

Which process will be active in time 120 ms when we use Round Robin scheduling policy with time-slice 20 ms?

- A P_1
- *B P_4
- C None of them, i.e., all processes were completed.
- D P_3
- E P_2

18 Consider the following truth table:

x	y	z	f
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

The output value f can be expressed as:

- A $f = \overline{\overline{\overline{\overline{\overline{x}} + \overline{\overline{\overline{y}} + \overline{\overline{\overline{z}}}}}}} + \overline{\overline{\overline{x}} \cdot \overline{\overline{\overline{z}}}}$
- B $f = \overline{\overline{\overline{x} \cdot \overline{\overline{\overline{y}} \cdot \overline{\overline{\overline{z}}}}}}$
- C $f = \overline{\overline{\overline{(x + y) \cdot (y + z) \cdot (x + z)}}}}$
- D $f = \overline{\overline{\overline{\overline{x} \cdot \overline{\overline{\overline{y}} \cdot \overline{\overline{\overline{z}}}}}}}}$
- *E $f = \overline{\overline{\overline{\overline{x} \cdot \overline{\overline{\overline{y}} \cdot \overline{\overline{\overline{z}} \cdot \overline{\overline{\overline{x}}}}}}}}}}$

19 Select the **false** statement about the computer representation of real numbers:

- A Different representations can be used for floating-point numbers and integers.
- B Real numbers are usually represented using the sign, exponent, and mantissa.
- *C A significant problem of all computer representations of real numbers is the so-called Boolean algebra problem.
- D Real numbers are often stored according to IEEE 754.
- E Some real number representations support the value of infinity.

20 Consider the following x86 program instructions and their interpretation:

```
MOV AL, 5 ; store value 5 into the register AL
MOV BL, 5 ; store value 5 into the register BL
CMP AL, BL ; compare values in the registers AL and BL
```

Which flag and how will it be changed by the instruction `CMP AL, BL`?

- A Direction flag is set to 1.
- *B Zero flag is set to 1.
- C Zero flag is set to 0.
- D Carry flag is set to 1.
- E Parity flag is set to 0.

Programming

21 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 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 III
- C I, II
- D II, III
- E I, III

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

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

23 Let us consider the following program. The print instruction outputs just the given number without printing any space or 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 243
 - D 4321
 - E The program will run forever and never halt.
-

24 Which statement is **false**?

- A** A tail-recursive function can always be rewritten in an iterative manner.
 - B** When using call-by-value, the change of a parameter value inside of a function cannot be observed from the outside of the function.
 - C** A recursive function can always be rewritten in an iterative manner.
 - D** In purely functional languages, functions can have no side effects.
 - *E** The strict evaluation strategy in functional programming allows working with infinite data structures.
-

25 Let us consider the following function:

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

Assume that $n > 0$. Which expression does the function compute?

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

Software engineering

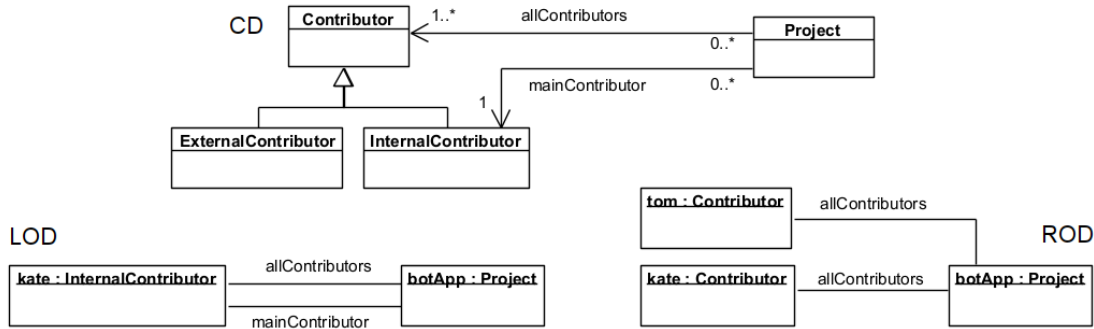
26 Which statement about the categorization of SW requirements is true?

- A** The division of functional and non-functional requirements is used to indicate inconsistencies in requirements.
 - B** Performance is a typical example of a functional requirement.
 - *C** Non-functional requirements can include statements about SW security.
 - D** Non-functional requirements describe the procedures that the system should not perform.
 - E** Functional requirements must always be specified before non-functional requirements.
-

27 As a software engineer, you shall select the best modeling notation (diagram) to represent a task schedule within SW development project planning. Which notation would you choose and why?

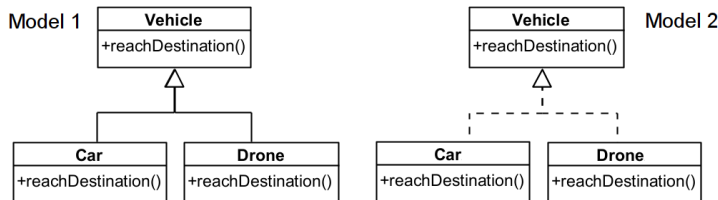
- A** the Boem Spiral Model - it supports the iterative nature of how we develop SW systems.
 - *B** the Gantt chart - it allows defining sequences of tasks over time for better control of the project and its risks of delays.
 - C** the Entity-Relationship Diagram - it is suitable for modeling project data, which is the crucial resource to manage.
 - D** the UML Sequence diagram - it is suitable for modeling human resources involved in the project, which is the crucial resource to manage.
 - E** the UML Sequence diagram - it is the most suitable UML diagram for capturing the timing behavior and planning aspects of any project.
-

28 Consider the three UML models in the figure, i.e., Class Diagram [CD], the left Object Diagram [LOD], and right Object Diagram [ROD]. Which statement about the 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 `botApp` project cannot have two different links (attributes) pointing to the same object. ROD is an instance of CD.
- C LOD is not an instance of CD because `allContributors` of `botApp` project links to an instance of `InternalContributor` instead of `Contributor`. ROD is an instance of CD.
- D LOD is not an instance of CD because `allContributors` of `botApp` project links to an instance of `InternalContributor` instead of `Contributor`. ROD is not an instance of CD because the main contributor is missing.
- *E LOD is an instance of CD. ROD is not an instance of CD because the main contributor is missing.

29 Choose the correct statement about the models below (class inheritance in Model 1, and interface realization in Model 2).



- A The difference is that while in interface realization (Model 2) the implementation of `reachDestination()` can either be inherited from `Vehicle` or overridden with specialized implementation, in inheritance (Model 1) the implementation of `reachDestination()` can only be inherited, not overridden.
- B The difference is that while in inheritance (Model 1) we could add `Airplane` as the third vehicle type, in interface realization (Model 2) `Airplane` cannot be added.
- C In both cases (Model 1 and 2), we could add a new instance attribute `maxSpeed` to `Vehicle`.
- *D In both cases (Model 1 and 2), the implementation of `reachDestination()` in `Car` can be different from the implementation of `reachDestination()` in `Drone`.
- E The difference is that while in interface realization (Model 2) we could add `Airplane` as the third vehicle type, in inheritance (Model 1) `Airplane` cannot be added.

30 Consider the two major directions of SW quality assurance - testing and static analysis. Which statement is true?

- A Type checking before code compilation is an example of testing (rather than static analysis).
- B Testing is more suitable to guarantee that no bugs are remaining in the source code.
- *C Static analysis typically focuses on the source code of the system, but it is also suitable to analyze models or design-time artifacts of the system.
- D Static analysis cannot be used for assessing system quality from the point of view of non-functional quality attributes.
- E Static analysis is more suitable to observe deviations of system behavior at runtime.

Tato strana je prázdná.