

University of Ljubljana  
Faculty of Computer and  
Information Science



Ljubljana,  
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## Catalogue of Knowledge

for enrolment into the  
second cycle Master's study  
programme

Computer and Information  
Science

2017/2018

## The Catalogue of Knowledge for the Selection Exam for Enrolment into the Second Cycle Master's Study Programme Computer and Information Science

### Programming

- basics of object-oriented and procedural programming
- program constructs for flow control (branching, loops, program structures)
- Iteration and recursion
- basic data types (integers, real numbers, strings, booleans) and operators
- exception handling

Magnus L. Hetland: Beginning Python, 2nd ed., Apress, 2008.

### Algorithms

- basics of algorithmic complexity (big-O notation)
- data structures (list, queue, stack, set, priority queue, hash table, trees, graphs)
- basic programming techniques (greedy search, divide and conquer, dynamic programming)
- standard algorithms (sorting, minimum spanning tree, shortest path search, etc.)

Kononenko et al. Programiranje in algoritmi, Založba FE & FRI, 2008.

or

Cormen et al.: Introduction to algorithms, 3rd ed., The MIT press, 2009, chapters 2, 3.1, 4.1, 7.1, 7.2, 10.1, 10.2, 11.2, 12.1, 12.2, 12.3, 15.1, 16.1, 22.1, 22.2, 22.3, 22.4., 23.1, 23. 2.

### Computer systems

- basics of digital circuits (Bool algebra, combinatorial and sequence logic, finite automata)
- number representation in computers
- basics of computer architecture

Kodek, Dušan: Arhitektura in organizacija računalniških sistemov, BI-TIM, Ljubljana, 2008 (ISBN 978-961-6046-08-4)

### Mathematics

- mathematical induction, complex numbers, polar form of complex numbers, sequences, series
- real-valued functions, derivatives, partial derivatives, gradient, optimization, integral
- analytic geometry in  $R^3$  (vectors, scalar product, vector product, lines and planes in  $R^3$ , projections, distances)
- matrix calculus, eigenvalues, determinants, systems of linear equations
- basics of statistics and probability

James Stewart: Calculus, early transcendentals, chapters 1-8, 11, 12, 14, H

Gilbert Strang: Introduction to linear algebra, chapters 1, 2, 4, 5, 6

# Sample Tasks for Elective Exams

## TASK 1

The following segment of program code is given:

```
count = 0
i = 0
while count < 1000:
    if random.random() < 0.3:
        i = i + 1
    else:
        if random.random() < 0.3:
            i = i + 2
        count = count + 1
print(i)
```

Explanation: The function `random.random()` returns a random real number from the interval  $[0.0, 1.0)$ .

What is the expected value of the variable `i` after execution of the above program?

- a) 600
- b) 720
- c) 840
- d) 880
- e) 900

## TASK 2

The following recursive function is given, which contains a part of the stopping criterion that is marked with yellow:

```
def fun_rek(n):
    if n ==         :
        return 2
    else:
        return n * fun_rek(n+1)
```

Which of the following values of the stopping criterion causes the call `fun_rek(2)` to return result 240?

- a) 6
- b) 10
- c) 32
- d) 80
- e) 120

### TASK 3

The following segment of a program code is given:

```
data = [[0,0,0,0],[0,0,0,0]]
for i in range(0, len(data)):
    for j in range(0, len(data[0])):
        if (i+j)%3 == 0:
            continue
        if (i+j) >= 3:
            break
        data[i][j] = i+j
```

Explanations:

- function `range(0,b)` returns a list of numbers `[0, 1, 2, ..., b-1]`,
- function `len(list)` returns a number of elements in list `list`,
- indexing of list elements in the above programming language starts with index 0.

What is the value of list `data` after the execution of the above code?

- a) `[[0, 1, 2, 3], [1, 2, 3, 4]]`
- b) `[[0, 1, 2, 0], [1, 2, 0, 4]]`
- c) `[[0, 1, 0, 0], [1, 0, 0, 0]]`
- d) `[[0, 1, 2, 0], [1, 2, 0, 0]]`
- e) `[[0, -1, 0, 0], [-1, 0, 0, 0]]`

### TASK 4

The functions `c` and `d` below call subroutines `a1`, `a2` and `a3` with the following computational complexities:

$a1 = O(n)$ ,  $a2 = O(n^3)$  in  $a3 = O(n \log n)$ .

```
void c(int n) {
    int z = 0 ;
    if (a1(n)+a2(n)*a3(n) > 1)
        z = 1 + a1(n) ;
    return z ;
}
```

```
void d(int n) {
    int i, j, s = 0 ;
    for (i=0 ; i < n ; i++)
        for (j=0 ; j < n ; j++)
            s = s + a3(n) ;
    return s ;
}
```

Select tight bounds for the asymptotic computational complexity of functions `c` and `d`.

- a)  $c = O(n^6 \log n)$  in  $d = O(n^2)$
- b)  $c = O(n^4 \log n)$  in  $d = O(n^3 \log n)$
- c)  $c = O(n^3)$  in  $d = O(n^3 \log n)$
- d)  $c = O(n^4)$  in  $d = O(n^3 \log n)$
- e)  $c = O(n^3)$  in  $d = O(n^2 \log n)$
- f)  $c = O(n^4 \log n)$  in  $d = O(n^2)$

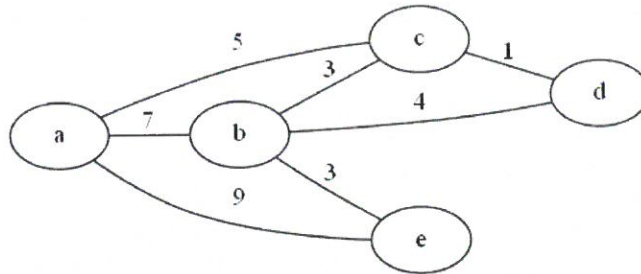
## TASK 5

In a program we use data structures stack, queue and priority queue (with smaller values having larger priority). Into the structures we insert the sequence of values: 5, 7, 12, 3 and 9. Which elements we get if we use operation pop on stack, dequeue on queue and deleteMin on priority queue?

- a) stack: 5, queue: 9, priority queue: 12
- b) stack: 9, queue: 3, priority queue: 12
- c) stack: 12, queue: 5, priority queue: 3
- d) stack: 36, queue: 5, priority queue: 5
- e) stack: 36, queue: 5, priority queue: 7
- f) stack: 9, queue: 5, priority queue: 3

## TASK 6

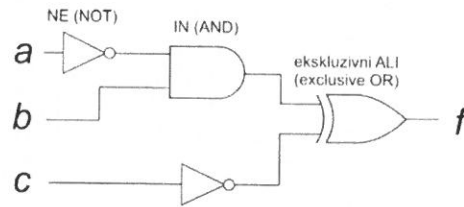
Find the cost of the minimum spanning tree for the graph below.



- a) 5
- b) 1
- c) 13
- d) 12
- e) 32
- f) 14
- g) 25

### TASK 7

Determine  $f(a,b,c)$  for two cases of logic values on the inputs:  $f(0,0,1)$  and  $f(0,1,1)$ .



- a) 0, 0
- b) 0, 1
- c) 1, 0
- d) 1, 1

### TASK 8

Minimize logic function  $f(x,y,z) = xz' \vee xyz \vee x'z'$ . ( ' stands for negation)

- a)  $xz' \vee x'z'$
- b)  $x'y \vee z$
- c)  $xyz \vee x'$
- d)  $xy \vee z'$

### TASK 9

Which decimal integer is represented by 0xE4 in the 8-bit two's complement notation?

- a) -28
- b) 28
- c) -228
- d) 228

### TASK 10

For which choice of a real number  $a$  are the line  $x = y - 1 = \frac{z+1}{2}$  and the plane  $ax + y + 2z = 3$  in  $\mathbb{R}^3$  parallel?

- a)  $a = -5$
- b)  $a = 0$
- c)  $a = 1$
- d) Nothing of the above.

### TASK 11

For which choice of a real number  $a$  does the following system of equations have a solution?

$$\begin{aligned}x + ay - z &= 0 \\x + y + 3z &= 12 \\y - 2z &= 3\end{aligned}$$

- a)  $a \neq 1$
- b)  $a \neq 3$
- c) System has a solution for every  $a \in \mathbb{R}$
- d) Nothing of the above

### TASK 12

Let a continuous and differentiable function  $f$  on the interval  $[-5,5]$  have its local maximum in  $(-2,3)$  and its local minimum in  $(1,-3)$ . Which of the following statements can be false?

- a)  $f'(-2) = 0$
- b) The graph of  $f$  has a tangent line at  $x = 1$  parallel to  $x$ -axis
- c) Maximum value of  $f$  on the interval  $(-5,5)$  is equal to 3
- d) The graph of  $f$  intersects  $x$ -axis and  $y$ -axis

### TASK 13

For given complex numbers  $z = 2 e^{i\frac{\pi}{2}}$  and  $w = \frac{1}{2} e^{i\frac{\pi}{4}}$ , what is the absolute value of the complex number  $\frac{z}{w}$ ?

- a) 1
- b) 4
- c)  $\frac{\pi}{4}$
- d)  $\frac{3\pi}{4}$