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EXCERCISES 1

INTRODUCTION TO COMPUTER SCIENCE

EX. 1. Draw an undirected graph. Convert it into a directed graph. Does this graph contain a cycle? If not, modify it to contain at least one.

EX. 2. Draw a clique and using the picture choose correct answers (many of them can be true). A clique is:

a) a graph in which each vertex is directly connected with every other vertex,

b) a directed graph,

c) an undirected graph,

d) graph *G4* (in the next page) is a clique of size 3,

e) graph *G5* (in the next page) is a clique of size 3,

f) the number of edges in a clique of size *n* is equal to $k(n)=k(n-1)+n-1$.

EX. 3. Draw a tree and mark the following nodes: the root, leaf, parent, child. Using the picture choose correct answers (many of them can be true). A tree is:

a) a directed graph,

b) an undirected graph,

c) in a tree a node can be a parent and a child at the same time,

d) in a tree all nodes are parents and children at the same time,

e) the root of a tree is a parent and a child at the same time,

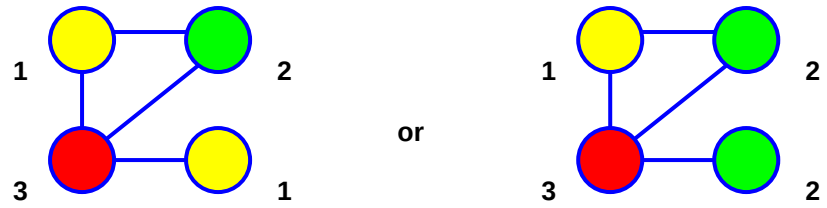
f) leaves in a tree are also parents of some other nodes.

What is the definition of the maximal depth of a tree? What is the maximal depth of the tree drawn by you?

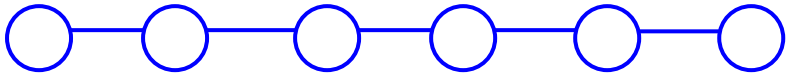
EX. 4. Draw an acyclic, directed graph (DAG). Is tree a DAG? Why?

EX. 5. A classical form of the graph coloring problem considers coloring of the nodes of an undirected graph. In a colored graph each pair of adjacent vertices (i.e. vertices connected by an edge) should have different colors and the number of colors used should be minimal. Below a correctly colored graph is presented (all adjacent vertices are colored differently), for which the minimal number of colors is used (using less colors would make the coloring incorrect).

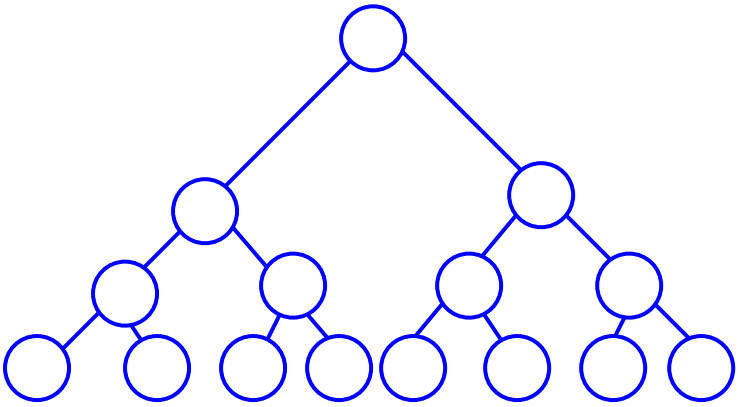
(*) asterisk marks problems which are not solved during exercise classes and should be solved as a homework



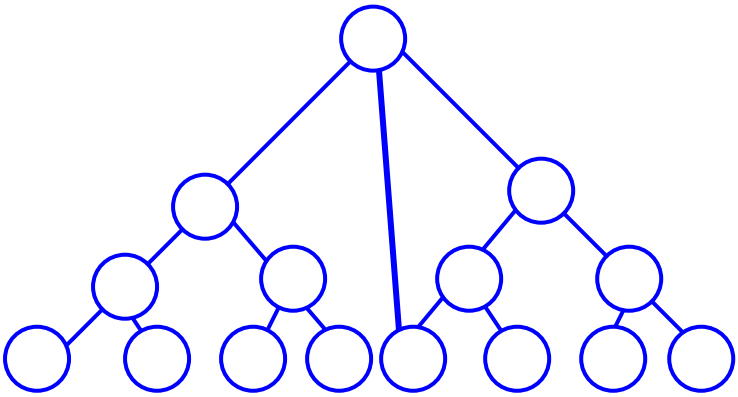
Color optimally (with the minimal number of colors) the following graphs:



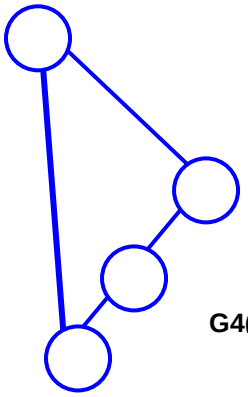
G1



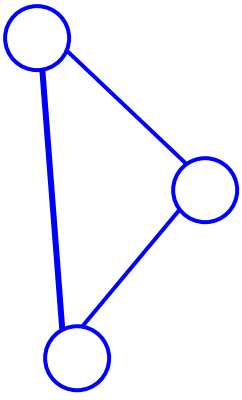
G2



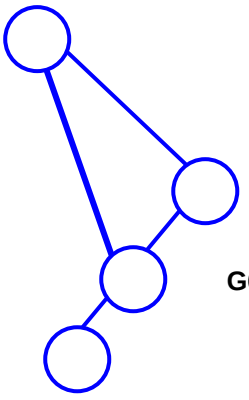
G3(*)



G4(*)



G5



G6(*)

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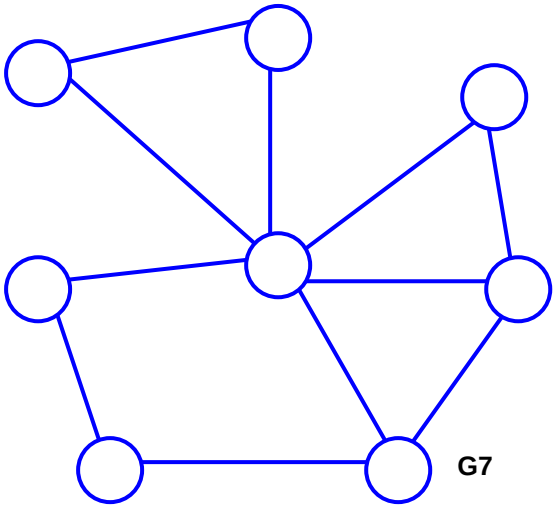
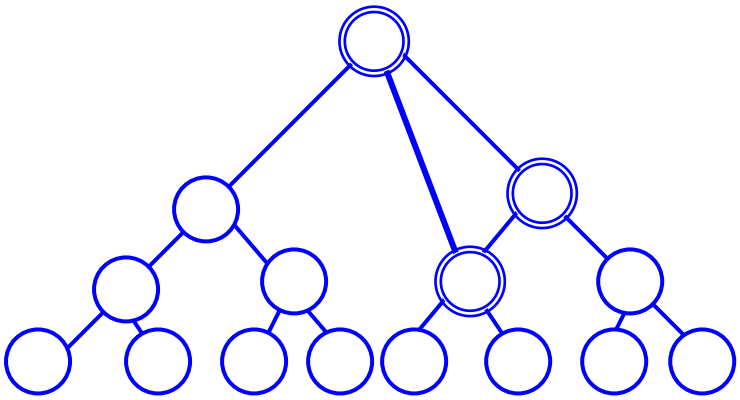


G7

EX. 6. How many colors are needed to color a graph being a clique of size *n*? Draw cliques whose sizes are *4* and *5*. How many edges are there in a clique of size *n*?

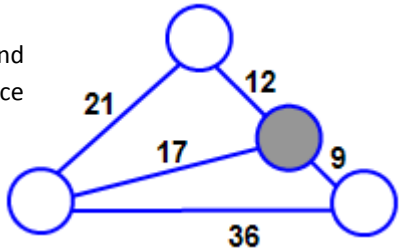
EX. 7(*). Color the graph G8 (to make it easier, the nodes that form a clique have a border drawn with a double line)



G8

EX. 8(*). How many containers are needed to transport a wolf (*W*), a goose (*G*), a goat (*T*), a carrot (*C*) and a hunting dog (*D*)? We assume that containers do not have any walls, cages, etc. We would like to use the minimal number of containers and transport all items safely. If we put everything into the same container then the goat could eat the carrot unless it was earlier eaten by the wolf, and the dog can bite the goose unless it is fighting with the wolf or – Solve the problem using graph coloring. How does the lack of knowledge about dog's intentions toward the goose influence the solution to the problem?

EX. 9(*). Given is a graph representing some map. The nodes correspond to cities and each edge is labelled with a number describing a distance between two cities.



Find such a route from the city marked with grey circle so that it goes through all the cities and the total distance is minimal. Obviously, if one edge is used twice, its length should be counted two times.

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EX. 10. Given is a chart that presents results of some algorithm, for example a dependency between an instance size and execution time. Can the chart be used to determine the complexity of the algorithm?

EX. 11(*). Given is a set of numbers $A = \{e_1, .., e_{10}\}$ with following values: *300, 99, 1, 102, 86, 114, 120, 120, 60, 400*. The task is to solve the set partition problem for the instance defined above.

EX. 12. Choose correct answers (many of them can be true). We distinguish the following algorithm complexity classes:

a) polynomial,
b) exponential,
c) NP-hard.

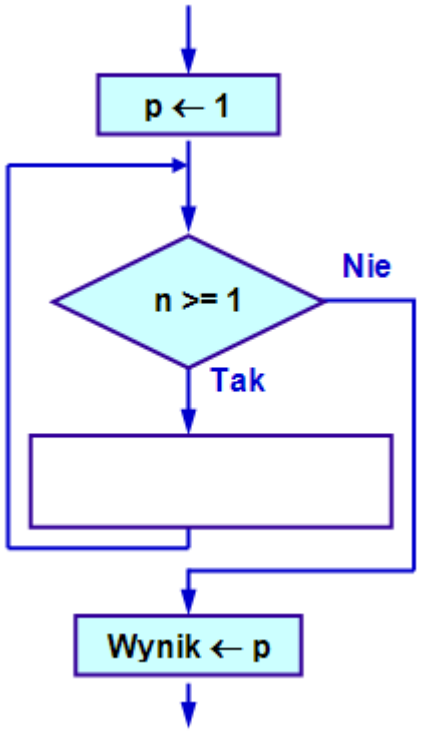
EX. 13. Choose correct answers (many of them can be true). We distinguish the following problem complexity classes:

a) polynomial,
b) exponential,
c) NP-hard.

EX. 14. Complete the given block diagram. After execution of the algorithm the expected result is *Wynik* = a^n, where *n* is a natural number (*n >= 0*).

Example:

a^n where *a=2* and *n=4* => 2^4=*2*2*2*2*



EX. 15. Draw a block diagram of an algorithm that calculates the greatest common divisor (GCD) of two integer numbers. **Input data:** *a, b* – numbers whose GCD should be calculated. **Result:** *GCD*.

```
if (a>b)
      a=a-b
else if (b>a)
      b=b-a
else NWD=a=b;
```

Example:

a=8, b=5

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a(8)>b(5) => a=8-5=3
b(5)>a(3) => b=5-3=2
a(3)>b(2) => a=3-2=1
b(2)>a(1) => b=2-1=1
a(1)=b(1) => NWD=1.

EX. 16(*). Draw a block diagram for an algorithm that calculates the *n*-th element of the Fibonacci sequence. **Input data:** *n* – index of the element to be calculated (*n>=3*). **Result:** *Fib(n)*.

Fib(1)=1; Fib(2)=1;
Fib(n)=Fib(n-2)+Fib(n-1);

Example:

Fib(n), for n=3?
Fib(3)=Fib(1)+Fib(2)=1+1=2.

EX. 17(*). Draw a block diagram for an algorithm that calculates the sum of digits of any given natural number *n.* **Input data:** *n* – a natural number. **Result:** *Sum(n)*.

Hint: Use the operators of the quotient *(div)* and the reminder *(mod)* to divide the input number *n* by 10.

Example:

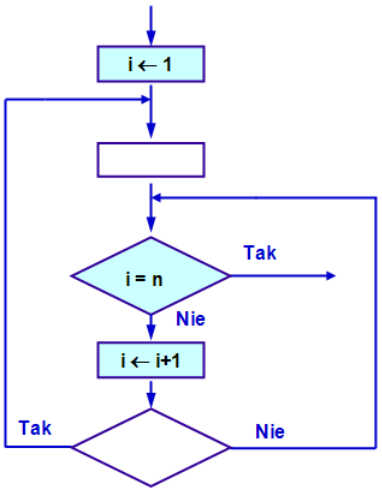
n=12 => Sum(n)=1+2=3.

EX. 18(*). Draw a block diagram for an algorithm that finds the minimal value *(min)* in a table of natural numbers. **Input data:** *n* – a table of natural numbers, *size(n)* – size of the table *n*. **Result:** *min*.

Example:

n = {1,3,2,4,2,7,3}, size(n)=7 => min = 1.

EX. 19. Complete the given block diagram. It should find the value *y=Max {xi}*, where *i* is natural number *<1,n>*.



EX. 20. Complete or choose the correct statement:

a) The virtual memory uses the algorithm of ..... when storing pages read from the disk in the memory.
b) Logical addresses *(ladrs)* point to: a) memory, b) disk.
c) Physical addresses *(fadrs)* point to: a) memory, b) disk.
d) The value of the *„Block"* cell in the page table describes .....

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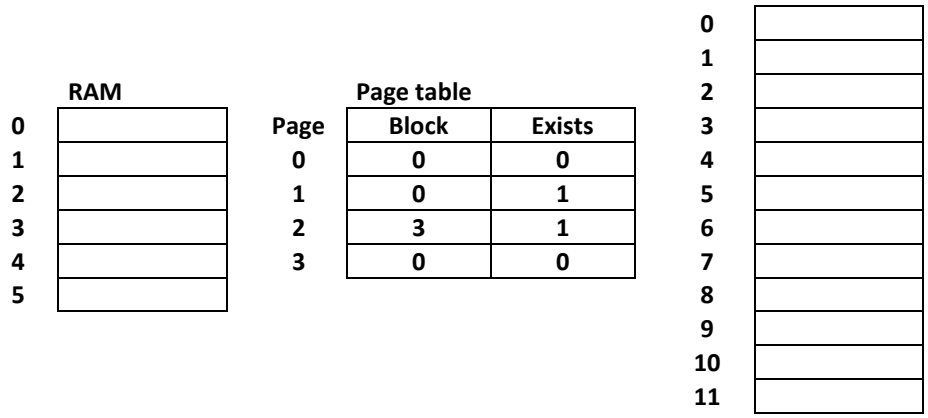
EX. 21. The page size in the virtual memory is equal to 3. The state of the virtual memory is presented in the picture below:



	RAM
0	
1	
2	
3	
4	
5	

Page	Block	Exists
0	0	0
1	0	1
2	3	1
3	0	0

0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	

Page table

Is the value of cell with logical address *1* stored in the memory (RAM)? How about the cell with logical address *7*? If it exists in the memory calculate its physical address. How the size of the page table can be decreased?

EX. 22. Virtual memory consists of *24* cells, which have logical addresses from *0* to *23*. A page of the virtual memory contains *4* cells. The memory consists of *8* cells, which have logical addresses from *0* to *7,* and is divided into *2* blocks, each consisting of *4* cells. The state of the virtual memory and the page table is presented below.

	Memory
0	**55**
1	**66**
2	**77**
3	**88**
4	**1111**
5	**2222**
6	**3333**
7	**4444**

	Page tb.
0	-1
1	-1
2	-1
3	**4**
4	**0**
5	-1

What is the value of virtual memory cells that have logical address *17* and *12*?

EX. 23(*). Virtual memory consists of *24* cells, which have logical addresses from *0* to *23*. A page of the virtual memory contains *4* cells. The memory consists of *8* cells, which have logical addresses from *0* to *7,* and is divided into *2* blocks, each consisting of *4* cells. The state of the virtual memory and the page table is presented below.

	Memory
0	**55**
1	**66**
2	**77**
3	**88**
4	**1111**
5	**2222**
6	**3333**
7	**4444**

	Page tb.
0	
1	
2	
3	
4	
5	

The task is to set page table content based on the assumptions defined below :

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ladrs=15 => fadrs=7, ladrs=4 => fadrs=0.

EX. 24. Choose correct answers (many of them can be true):

a) a compiler consists of analyzer and generator,
b) an analyzer is sometimes called *„backend”*,
c) a generator is sometimes called *„frontend”*,
d) an analyzer is sometimes called *„frontend”*,
e) a generator is sometimes called *„backend”*,
f) when new processors, which include more efficient instructions set, are designed the new version of analyzer is designed during the compiler development process,
g) when new processors, which include more efficient instructions set, are designed the new version of generator is designed during the compiler development process.

EX. 25. Why computational errors should be taken into consideration during numerical analysis? (define at least two possible answers)

EX. 26. What representation form of the floating-point numbers should be used during computation in order to have an information about possible result error?

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