Tasks T1 – T10 carry 3 points each

T1: Trees

Beaver's family is building a dam from lots of trees. Every tree should be prepared by following a special sequence of three steps. At first, father gnaws a tree (which takes 30 minutes), then mother hauls that tree toward the bank (which takes 30 minutes), and little beavers gnaw all branches from the tree (which takes 30 minutes).

		
Father gnaws the tree	Mother hauls the tree	Little beavers gnaw all branches

What is the shortest time required to prepare three trees?

A) 90 minutes **B)** 120 minutes **C)** 150 minutes **D)** 270 minutes

It's informatics!

CPUs are working in a similar way as the tree preparation. If every device is used as soon it is free, computation becomes faster. Pipelining is an important idea for constructing CPUs. It's a cheap way to speed up computation. This task also deals with parallel processing, where tasks which do not conflict can be run simulatenously. Most of today's CPUs are multi-core machines, which can accomplish some of this parallelism. Parallel processing is an important algorithmic technique, which can be applied Something about factories producing cars.

Keywords

Preparation/prepare

T2: Family Tree

The beaver brothers want to draw the family tree. They talk to older beavers of the family and write down what they learn about relationships. When they write parent (A,B) they mean that A is the parent of B. Here is the list they got:

Parent (Thomas, Peter).
Parent (Ann, Eve).
Parent (Reka, George).
Parent (Margaret, Ann).
Parent (Ann, Zoltan).
Parent (Peter, George).
Parent (Charles, Zoltan).
Parent (Margaret, Peter).
Parent (Thomas, Ann).
Parent (Charles, Eve).

Find all grandparents of Zoltan among beavers mentioned in the list.

A) Ann and Charles. **B)** Eve and Thomas. **C)** Margaret and Thomas. **D)** Only Margaret

It's informatics!

Information coding for computer can be on different level in different forms. The languages of artificial intelligence have back step logic what ensures to find right answer if it is exists.

Keywords

AI
Prolog
Backstep
logic

T3: Truth

Beaver Bob only tells the truth on Monday, Wednesday and Friday and always lies on all other days.
Today he says: “Tomorrow I’ll tell the truth.”

What day is it?

A) Tuesday **B)** Friday **C)** Saturday **D)** Sunday

It's informatics!

Logic is fundamental in computer science. When designing computer programs, careful thought has to go into logic structures. So complex computations can be made much more efficient, like instead of trying every possible way, one can exclude beforehand much useless computations (like trying all weekdays).

Keywords

Algorithm
Logic programing
Prolog

T4: Mobile phones

The beaver family has three mobile phones with empty batteries.
It takes 1 hour to fully recharge a mobile.
The beaver family has only two sockets and two mobile phone chargers in the house to charge the mobiles.

What is the shortest time they need to fully recharge the three mobiles?

A) 3 hours **B)** 2 hours **C)** 1 hour and half **D)** 1 hour

It's informatics!

This is a scheduling problem. Scheduling is used in computer science when tasks may be performed faster by dividing them among many CPUs: we choose which CPU will work on which task, when, and for how long. There are many different algorithms for scheduling. The most simple one is "first come, first served": you perform the tasks in the order they arrived. Here it would be to fully charge mobiles 1 and 2, and then charge mobile 3. But here this is not optimal as to the date of end for the whole work. When we need to divide tasks, it is important to choose carefully the way we assign them, so as to optimize one particular objective (date of end for instance). Scheduling is also used in disk drives (I/O scheduling), printers, net routers etc. Usually scheduling problems are very hard problems. We do not know how to solve them efficiently, or even if it is possible to do so.

Keywords

Scheduling

T5: Abacus Factory

Beavers like to compute. As the tasks get more and more difficult, they start using simple computers: abaci. Ann, Kate and Philip established an abaci factory.

Making one abacus takes three steps:
1. Put rods into the left part of the frame.
2. Add the beads on the rods.
3. Add the rest of the frame.

Ann, Kate and Philip are not equally fast. The table below gives the times (in minutes) that they need for each operation.

	Putting rods into the left part of the frame	**Putting beads on the rods**	**Adding the rest of the frame**
Ann	10	15	15
Kate	10	20	10
Philip	15	10	15

If they have only two hours, how should they organize to assemble as many abaci as possible?

A) Each of them makes abaci alone.
B) Ann puts rods into the left part of the frame, Philip adds beads, Kate adds the rest of the frame.
C) Philip puts rods into the left part of the frame, Kate adds beads, Ann adds the rest of the frame.
D) Ann and Kate put rods into the left parts of the frames, Philip adds beads and the rest of the frame.

It's informatics!
These kinds of pipelines, where the output from one worker or machine or factory is input for another one and work is done parallel, are common in many areas of everyday life: factories, offices, transport systems, etc. It is important to optimize these processes to get best results. Often the processes are too complicated to be optimized by hand and computers must be used. Also note that (just like in this task), a process may have a start-up delay where the time from beginning to the first output is much longer than the time between subsequent outputs. Computer chips are also often composed of multiple units that can work in parallel, but need input from each other, much like Ann, Kate and Philip. Nowadays, when the actual speed of processors mostly stopped increasing, we make them faster by introducing more parallelism and better constructed “pipelines”.

Keywords
Pipeline

T6: Give me the change!

Beaver Anthony bought a great European oak wood plank for his lunch. The plank costs 79 beavlars and he only has one 100 beavlars note. The seller has to give him back the change, but only has the following coins denomination (he has unlimited number of each coin):

- 14 Beavlar
- 9 Beavlar
- 3 Beavlar
- 1 Beavlar

How many coins will he receive back, at least?

A) 2 **B)** 3 **C)** 4
D) The seller cannot give him back the exact change.

It's Informatics!
This is informatics because it is an optimisation problem, it is the change problem. This variant is particularly interesting since the denominations make it not possible to use the naïve algorithm that is for example used by cashiers when they have to give back the change to customers.

Keywords
Change proble
Optimisation
State-Exploration

T7: Lazy Beaver

A lazy beaver hires five strong beavers to work for him. Everyday, each working beaver receives instruction to either collect logs from the forest and bring to the warehouse, or take logs away from the warehouse for processing. If a beaver is on vacation, he does not add or remove logs from the warehouse. The warehouse initially has 100 logs.

	Collect	**Process**
Beaver A	add 81 logs to warehouse	Take away 81 logs from warehouse
Beaver B	add 27 logs to warehouse	Take away 27 logs from warehouse
Beaver C	add 9 logs to warehouse	Take away 9 logs from warehouse
Beaver D	add 3 logs to warehouse	Take away 3 logs from warehouse
Beaver E	add 1 logs to warehouse	Take away 1 logs from warehouse

For example, if Beavers A and D are on vacation, Beaver B's order is "Collect" and Beavers C and E's are to "Process", then at the end of the day, the warehouse will have 100+27-9-1 = 117 logs.

What is the work order of each beaver if the warehouse is to have 168 logs at the end of the day?

A) Collect: Beavers A, D, E; Process: Beavers C, D.
B) Collect: Beavers A, E; Process: Beavers B, D; Vacation: Beaver C.
C) Collect: Beavers A, B; Process: Beavers D, E; Vacation: Beaver C.
D) Collect: Beaver A; Process: Beavers C, D, E; Vacation: Beaver B.

It's informatics!
Some early computers were based on a ternary system. Instead of machines being based on a binary system (0 or 1; true or false; on or off) like computers today, these older computers were based on three possible values. They had some computational advantages.

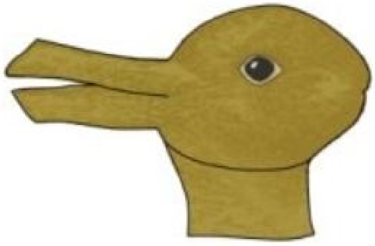
Keywords
Balanced ternary numbers
Setun

T8: Laterality

Psychologists made a test of laterality in the classroom consisting of three tasks and answers were stored in a computer. The tasks were:

1. Clasp hands: they recorded whether left or right thumb was above.

2. Look at the picture and immediately tell, which animal do you see: they recorded whether student saw a head of rabbit or duck.



3. Give a clap: they recorded whether left or right hand was above.

The psychologists have to come up with a different code for each possible outcome of the three task test.
How many different codes should there be at least?

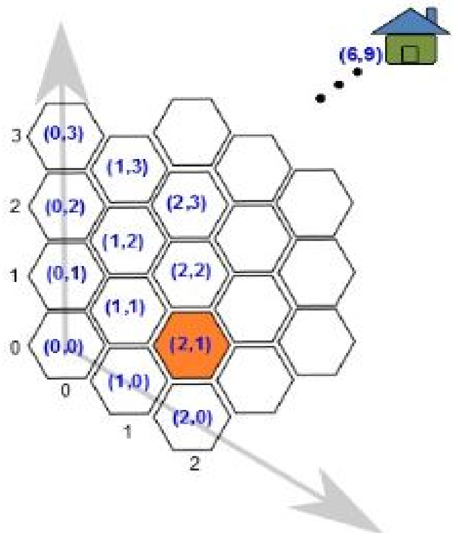
A) 1 **B)** 3 **C)** 8 **D)** 16

It's informatics!
Encoding of information is one of the basic problems in informatics. Moreover, the codes have to be designed in a such a way that they are from a rich enough domain that one can distinguish between different information.

Keywords
Information units
Digital literacy

T9: Moving in Hexagonal Grids

Beavers love the shape of hexagons, so they decided to divide their country into several hexagonal cities. They set a coordinate for each city (see the figure), and set the distance between two neighboring cities is 1. One little beaver is currently in the city (2,1) and its home is in the city (6,9).



What is the shortest distance between the little beaver's current position and home?

A) 6 **B)** 7 **C)** 8 **D)** 9

It's informatics!

Hex coordinates are commonly used in computer games or computer graphics. Calculating distances between grids in hex coordinate is the basis of using hex coordinates. In addition, since students are already familiar with Cartesian coordinates, it is a good practice for students to compare the differences between Cartesian coordinates and hex coordinates.

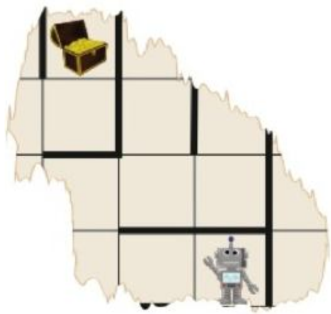
Keywords

Hex coordinate

T10: Through the Maze

Last year, there was a competition in which the beavers had to retrieve a treasure from a maze using a robot. There was only a single path leading to the chest. The robot was very fragile, so they had to be careful not to hit any walls.

This year they must repeat the endeavor, but a hungry young beaver ate most of the map! This is all that remained.



Last year, they used one of the following paths to guide the robot to the treasure chest and back, but they forgot which one. Help them!

A) LLURUURULLLDDRUDLUURRRDLDDLDRR
B) LLURULURULLDDRUDLUURRDRLDDLDRR
C) LLURUURULLLLDRUDLURRRRDLDDLDRR
D) LLLLLULUURDRURRRLDLULDDRURRRRL

It's informatics!
When a program fails, programmers must find the errors by either tracing its execution, as we did for answers C and D, or by finding more clever ways of discovering what may be going wrong, like for answer B, where we discovered that the program is not symmetric in the way it ought to be.

Keywords
Programming
Debugging

Tasks T11 – T20 carry 4 points each

T11: Bagels

Two friends have opened a bakery. Sue bakes three bagels (one of each shape A, B and O) and hangs them together on a stick, placing A on first, then B on second, and O third. She then repeats this process. Peter is selling the bagels and takes always the right-most bagel from the stick. Sue is baking faster than Peter can sell the bagels.

What is the fewest number of bagels sold by Peter if the bakery looks like the above picture?

A) 9 bagels **B)** 7 bagels **C)** 11 bagels **D)** 5 bagels

It's informatics!

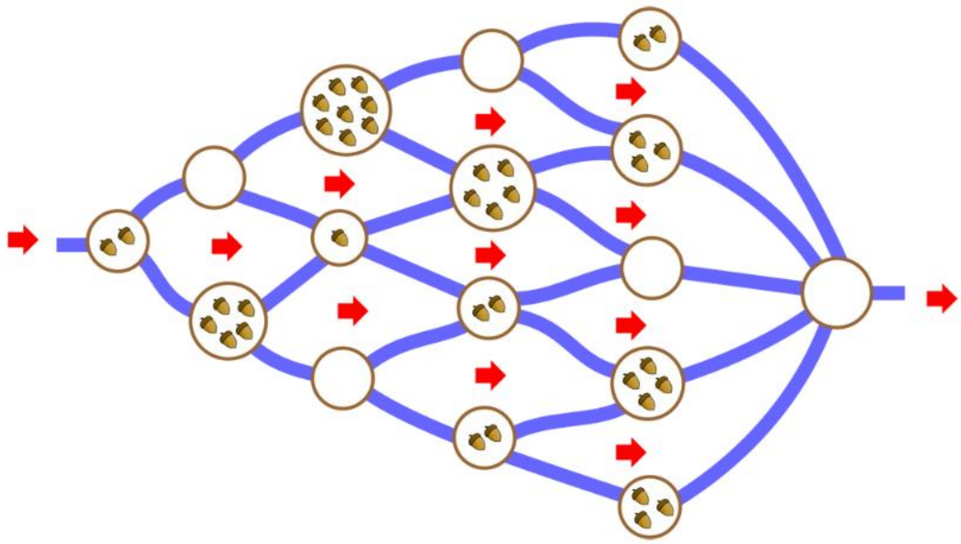
The management of a data structure, namely a stack, is shown. When using a stack, elements can be stored only at the uppermost position and can be taken only from the uppermost position. That is, a stack is a LIFO data structure: last-in, first-out, meaning the most recently placed item into the stack will be the first item removed from the stack.

Keywords

Stack
Data structure

T12: Collect the acorns

Beaver Billy is fond of acorns. He wants to swim down the river and collect all acorns on the islands that he can pass by. Alas, the current is strong, so he can only swim downstream.



What is the maximum number of acorns that he can take?

A) 13 **B)** 15 **C)** 16 **D)** 18

It's informatics!

Finding the best possible value when there are a lot of options, for instances different routes the taken, is a common problem where a computer program can be used. The algorithm to find the solution for this problem is called dynamic programming. It is used when you want to avoid to make the same calculations over and over again. In stead of these calculations, a table is used. Algorithms to find a quick solution are very important in computer science.

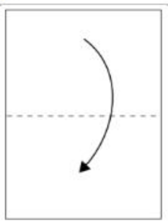
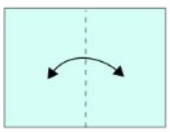
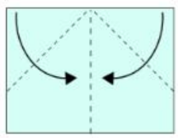
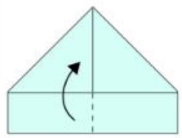
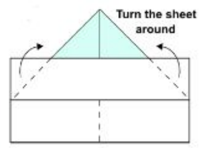
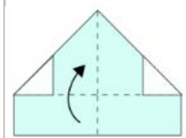
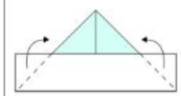
Keywords

Dynamic programming

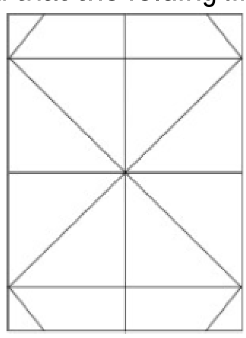
Optimizing

T13: Origami sheet

Martin followed instructions 1-7 below to create a cap by folding a sheet of paper. One side of the paper is white and the other one is light blue:

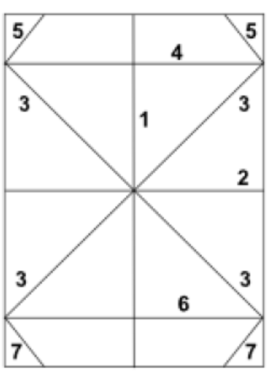
1.	2.	3.	4.	5.	6.	7.
						
Fold the sheet's top to its bottom.	Fold the left side to the right one and then back.	Fold the top corners so that they touch each other.	Fold the front extra lower part of the paper upwards	Fold the corners backwards and then turn the whole assembly around horizontally.	Fold the front extra lower part of the paper upwards	Fold the corners backwards.

Martin then unfolded the cap and observed that the folding lines were visible on the paper.

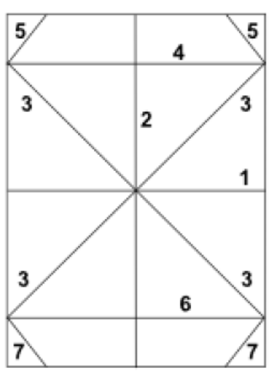


He started thinking about which folding line was produced by which instruction step.

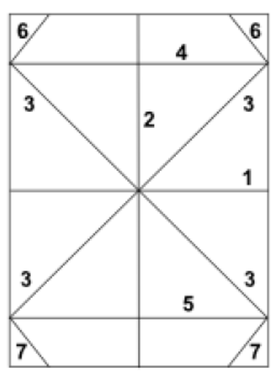
Which picture shows the correct association of folding lines with instruction steps? The numbers in the pictures correspond to the instruction numbers above.



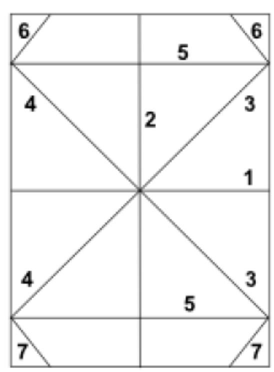
A)



B)



C)



D)

It's informatics!

To be able to understand a sequence of actions precisely expressed in a specific language (for example a graphical one like in this task) is an important for programming (writing computer programs, which is an important part of informatics). When programming, it is also very important to look at the result of a program and understand which parts of the result were created by which part of the program. This helps to debug programs, i.e. to find incorrect parts of the result and the corresponding incorrect parts of the program.

Keywords

Origami
Pictorial algorithms
Debugging

T14: Binary one half

The only digits in binary are 0 and 1. (A subscript 2 indicates that the number is written in binary). The numbers 1 to 6 can be written in binary as 1_2, 10_2, 11_2, 100_2, 101_2 and 110_2 . Note the following important numbers 1 = 1_2, 2 = 10_2, 4 = 100_2, 8 = 1000_2 and so on. Of course, even fractional numbers can be written in binary.

How can the number 0.5 be written in binary?

A) 0.1_2 **B)** 0.101_2 **C)** 0.5_2 **D)** 0.2_2

It's informatics!

Computers internally work with binary numbers only. The system to represent positive integer numbers can be extended to binary fractions (in an analogue way to decimal fractions). Interestingly, like 1/3=0.33333... in decimal, the number 0.2 cannot be represented as a finite binary fraction: 0.2 = $0.001100110011..._2$

Keywords

Binary numbers
Binary fraction
Floating points numbers

T15: Birthday party

Beaver Louis remembers his wonderful 10th year birthday, but he is a bit worried because now he has to prepare a new birthday party. He only knows these two recipes:

For 5 pancakes	For 1 cake
100 g of flour 20 ml of milk 1 egg	100 g of sugar 100 g of flour 100 g of butter 2 eggs

On his shelf, he only has the following ingredients:

- 6 eggs;
- 200 g of butter;
- 500 g of sugar;
- 500 g of flour;
- 60 ml of milk.

He can do any of the two recipes more than one time, but he cannot do any recipe partially (that is preparing half a cake or only one pancake, for example).

Beaver Louis wants to use the maximum ingredients and searches for the best combination between the two recipes. Which of the following statements is true?

A) No matter which combination, some sugar will always remain.
B) No matter which combination, some milk will always remain.
C) It is possible to use up all the ingredients.
D) It is impossible to cook both recipes.

It's informatics!
That problem is related to constraint programming, where a solution to a problem under constraints have to be found. One way to solve the problem is to explore the whole state space of solutions.

Keywords
Constraint programming
Chinese remainder theorem
Combinatorics

T16: Some strange words

Beavers consider words containing only the letters a, b, c. They can do three operations on such words:

1. Replace every **a** with the sequence **aa**.
2. Replace some **b** with **c**.
3. Insert the letter **c** anywhere in the word.

For example, if we have the word abbbcaab then using instruction 1 we would get **aa**bbbc**aaaa**b, then using instruction 2 we would get aab**c**bcaaaab, and finally using instruction 3 we would get aabcbcaa**c**aab.

Which of the following words is impossible to get if we start with aabbbbaabbccbbabbc?

A) abbbaabbccbaaaabbc
B) aaaaccbbaacaaccccbbaabbc
C) caaccccaacccccccacccc
D) acacbcbcbcbcacacbcbcccccbcbcacbcbcc

It's informatics!

Programs usually consist of statements. Since programming languages must be clear and concise, the form of the statements is described by strict sets of rules similar to those above. We prescribe the form and define its meaning, and, voila!, we have a programming language.

How about the rules of the English language? Could we also describe how to properly form English sentences? It turns out we can – to some extent –, and it also helps us attach the meaning to them. When you use a computer to translate some text from a foreign language, the computer needs to analyze and synthesize its sentences in such a way. If you are used to seeing poor translations, this is mostly because the human languages are so much more difficult to describe than programming languages.

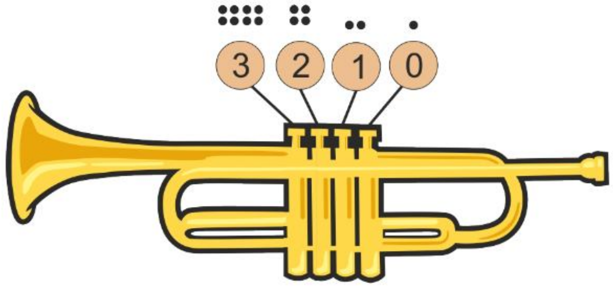
Therefore, if you learned to speak and understand English, programming should be a piece of cake for you.

Keywords!

Formal languages theory
Turing machine
Grammar

T17: Binary Trumpet

The binary Beaver trumpet has four numbered valves so you can play a range of 16 pitches. The lowest pitch is played if all valves are open and is represented by zero black dots. The highest pitch is played when all valves are pressed and is represented by 15 black dots. Generally, the more black dots you accumulate by pressing valves the higher the tone.



For example: 2 & 0 represents that the valves 2 and 0 are pressed and pitch #5 (4+1) is played. 3 & 1 & 0 represents that the valves **3, 1 and 0** are pressed and pitch #11 (8+2+1) is played. Because Pitch #5 is lower than pitch #11 these two tones are ordered increasingly.

Which of the following four-tone sequences is ordered by increasing pitches?

	1st tone	2nd tone	3rd tone	4th tone
A)	2 & 1 & 0	3 & 0	3 & 2 & 1 & 0	1 & 0
B)	1 & 0	2 & 1 & 0	2 & 1	3 & 1 & 0
C)	2 & 1 & 0	3	3 & 0	3 & 2 & 0
D)	3 & 0	3	3 & 2 & 1 & 0	3 & 2 & 1

It's informatics!

There are two ways to solve the task. The innocent one is to simply count and accumulate the black dots each cell and compare them tone for tone.

The smart way is to recognize the logic of the binary numeral system. Use 2 as base number and the hole numbers for power and you get:

empty = 0
2^0 = 1
2^1 = 2
2^2 = 4
2^3 = 8

So the black dots stand for the result of two powered by the particular hole number.

Keywords

Binary numeral system, pitch (music)

T18: Binary counter

Little beavers use a weird counter, which only uses two digits: 0 and 1. Every time the counter is pressed, it changes the rightmost 0 to 1, and every digit 1 on its right to 0.

For example, when it is pressed:

- the number 01001 changes to 01010.
- the number 01011 changes to 01100.
- the number 01111 changes to 10000.

The first number in the counter is 00000. After how many presses will the counter show 11111?

A) 15 **B)** 16 **C)** 31 **D)** 32

It's informatics!

The described numbers are binary numbers, which represents values using two symbols, typically 0 and 1. The reason for this is that there are only two states an electrical circuit can be in: either off or on. Since computers can only understand either 0 (off) or 1 (1), they use the binary number system.

Keywords

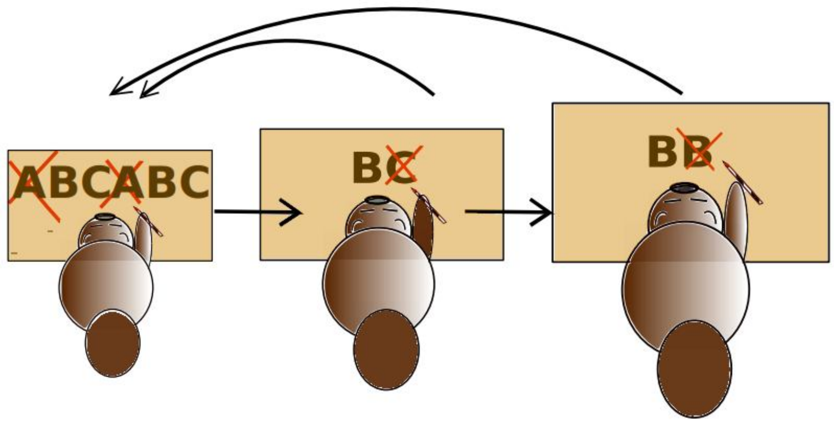
Binary number

Number system

T19: The New Forest Times

Three beavers work as correctors in the “The New Forest Times” newspaper. They try to make articles more understandable for animals in the forest.

1. The young corrector reads an article from left to right, searches for the **ABC** sequence, and replaces it with **BC**. If he finds and replaces this sequence, he has to start again from the beginning. If he does not find the sequence, he gives the article to the professional corrector.
2. The professional corrector reads an article from left to right, searches for the **BC** sequence, and replaces it with **B**. If he finds and replaces the sequence, he returns the article to the young corrector. If he does not find the sequence, he gives the article to the chief corrector.
3. The chief corrector reads an article from left to right, searches for the **BB** sequence, and replaces it with **B**. If she finds and replaces the sequence, she will return the article to the young corrector. If she does not find the sequence, the correction process is finished.



Which of the following articles will NOT be corrected to a one-letter article **B**?

A) AAABCB **B)** ABCABC **C)** ABABCB **D)** ABCCCC

It's informatics!

The correction process is a description of a Markov algorithm. As Turing machines, Markov algorithms formalize the notion of an algorithm, everything that can be computed by a machine, may also be computed by some Markov algorithm and vice versa.

Keywords

Markov algorithm
Normal algorithm

T20: Phone Bills

A communications company stores billing information. There are exactly three charges for each customer (for data, voice and text). Each customer has his or her own unique and distinct phone number. There are two options for storing this data.

OPTION A

Store all the information in one table. Each row in the table corresponds to a data charge, voice charge or text charge. For example:

NAME	PHONE	NUMBER TYPE	CHARGE
Aki	458-6578	data	10.00
Aki	458-6578	voice	15.00
Aki	458-6578	text	10.00
Vlad	235-8998	data	40.00
Vlad	235-8998	voice	40.00
Vlad	235-8998	text	30.00
Mia	515-6632	data	25.00
Mia	515-6632	voice	20.00
Mia	515-6632	text	20.00

OPTION B

Store the phone number for each customer in one table. Store the charges in a second table in which each row corresponds to a data charge, voice charge or text charge. For example:

NAME	PHONE NUMBER
Aki	458-6578
Vlad	235-8998
Mia	515-6632

PHONE NUMBER	TYPE	CHARGE
458-6578	data	10.00
458-6578	voice	15.00
458-6578	text	10.00
235-8998	data	40.00
235-8998	voice	40.00
235-8998	text	30.00
515-6632	data	25.00
515-6632	voice	20.00
515-6632	text	20.00

The amount of storage is measured in bytes. Each name requires 128 bytes. Each type requires 1 byte. Each phone number and charge requires 4 bytes. These measurements do not depend on how long names are or how big charges are.

Suppose A and B are the amounts of storage required by options A and B respectively. If the company has 1000 cell phone customers, which of the following statements about the needed amount of storage is true?

A) B needs more than twice as much as A (B > 2A)
B) B needs more, but not twice as much (B > A, but B < 2A)
C) A needs more than B, but less than twice more (A > B, but A < 2B)
D) A needs more than twice as much as B (A > 2B)

It's informatics!

A database stores a large amount of information for a long period of time. This data is often placed in tables. Expertise is required to determine the number of tables and which information is placed in which table. Different designs must try to balance the amount of memory used with the amount of time that will be needed to answer questions (called queries) about the data.

Keywords

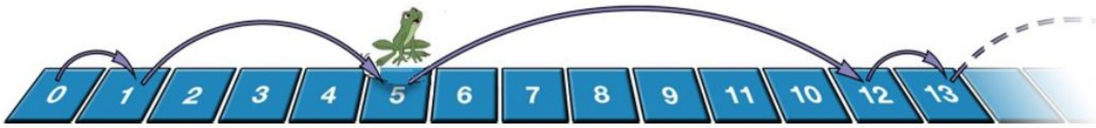
Byte

Relational database

Tasks T21 – T30 carry 5 points each

T21: Jump sequence

Sven the frog is playing a jumping game on numbered squares. He starts on square 0 and then jumps 1 step forward, then 4 steps, then 7 steps, then again 1 step, then 4, and so on, repeating forever. A square is good if Sven visits the square during his game.



Which of the following sequences of squares contain only good squares?

A) 38, 59, 124 **B)** 36, 61, 125 **C)** 38, 60, 124 **D)** 36, 59, 125

It's informatics!

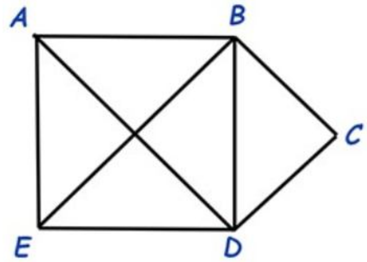
When faced with an algorithm, such as Sven's jump sequence, it's often useful to execute the algorithm for a few steps to try to discover a pattern. From this pattern, it might be possible to derive a more efficient way of solving the problem than naively running the algorithm.

Keywords

Algorithm
Modulus

T22: Painting robot

Beaver-tennis is played on an odd-shaped court shown below.



Beaver uses a robot to paint lines for the court. To save paint, Beaver wants to paint all the lines without painting any lines twice. The painting robot can only be switched off when it has finished painting.

Find the way to paint the tennis court without painting any lines twice.

A) A → B → C → D → E → B → D → A → B
B) A → D → B → E → D → C → B → A → E
C) A → D → B → E → D → C → B → A
D) E → A → D → E → B → C → D → E

It's informatics!

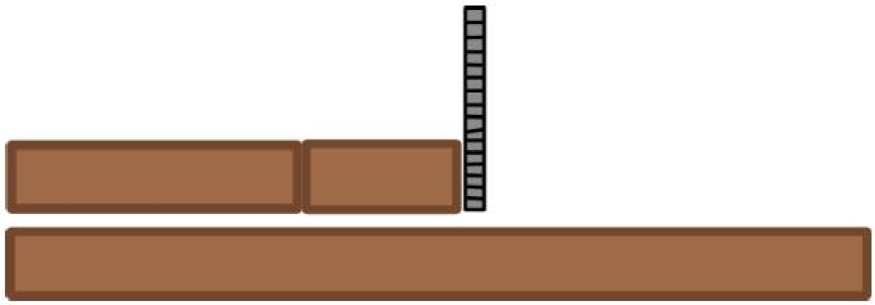
This problem is the Eulerian tour problem. That is finding a path in a graph that visits every edge of the graph exactly once. Such Eulerian trails are used in various domains such as bioinformatics or circuit design.

Keywords

Graph
Eulerian tour
Path

T23: Cutting pipes

Xavier has pipes of length 4, 7 and 100 meters. For a new project he needs a pipe of 13 meters. Unfortunately, Xavier lost his tape measure. All he has now is a machine that cuts a pipe using the existing pipes and any new lengths produced from them as a reference measure.



Xavier wants to keep as much of the 100-meter pipe intact as possible.

How long is the longest possible pipe after producing a 13-meter pipe?

A) 87 **B)** 82 **C)** 81 **D)** 76

It's informatics!

That problem is an optimization problem, where the state space has to be searched to find a solution that minimises the number of cuts of the main log of 100m.

Keywords

Combinatorics
Optimization
Scheduling

T24: Robber language

In the "robber language" (used in Astrid Lindgren's children's books about Kalle Blomkvist), each consonant in a word is replaced with a combination: the consonant, then 'o', and then the consonant again; while the vowels are left unchanged.

For example, the word “beaver” becomes “bobeavoveror”.

Beaver Oskar encrypts his passwords with the robber language, and for additional security he does not always change all the consonants. So if he has written "dodog", the original password could have been either "dog" or "dodog".

On one note, Oskar has written "boboboborororhejmowowdor". How many different passwords could be encrypted there?

A) 7 **B)** 12 **C)** 16 **D)** 24

It's informatics!

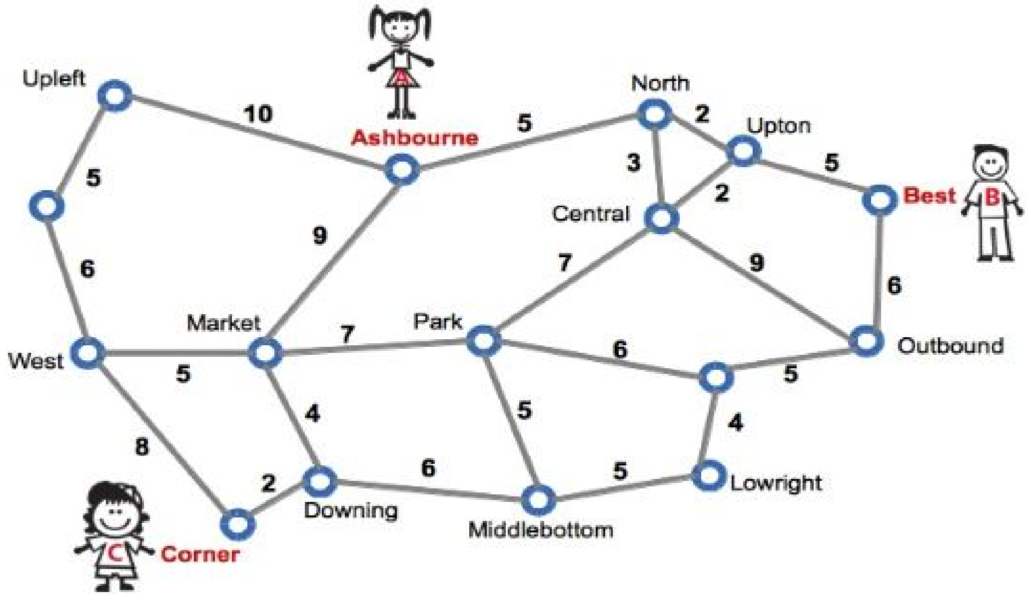
A very useful strategy in computer science is to break down the problem into smaller subproblems. Sometimes these are completely independent, as in this case. If the subproblems are interconnected, a more sophisticated algorithm is usually required.

Keywords

String algorithms

T25: Meeting

Anna, Bert, and Claire live in a city with a good subway network. Below, you see a map of this network. The map shows the subway stations and their connections. The numbers show the cost in Beav (the local currency) to travel between two neighbouring stations.



Anna lives close to station Ashbourne, Bernie lives close to Best, and Claire lives close to Corner. They want to meet at some station on the map. None of them, however, can spend more than 15 Beav in the subway, and they do not want to travel by feet.

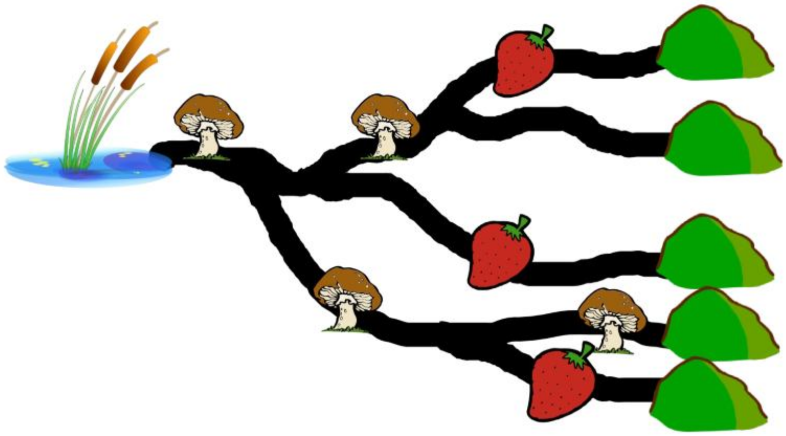
Where could they meet?

A) Central **B)** Market **C)** North **D)** Park

It's Informatics!
The mathematical concept of a relation is heavily employed in the area of informatics. Large databases rely on so-called relational models. A specific perspective on relations between elements of the same set is taken in a "graph": the elements are called "nodes", and "edges" are pairs of related nodes. In specialized graphs, edges may have a direction (node a is related to node b, but not vice versa) or weights. A traffic network like the one of this task can nicely be modeled - and visualized - as a graph with weighted edges, with the weights representing the cost or the traveling distance. The good thing is that informatics has developed many efficient algorithms for such graphs, e.g. several ones to find shortest paths (i.e. a sequence of edges) between nodes in a graph. Obviously, shortest path algorithms are useful for route planning - and many other applications. For instance, if you want to go from one station with another as fast as possible, if you ask the transportation website for the route, it will compute the shortest path. The algorithm we used here to compute shortest paths is called Dijkstra's algorithm.

T26: Walk in the forest

There are 5 roads in the woods. Each one is starting at the Beaver pond (left side of the picture) and end at one of the five hills in the woods (right side of the picture). Each road consists of sections. A road section is a part of the road between two intersections or an intersection and an end of the road. As you see from the picture, some sections can belong to several roads. It is possible to find mushrooms or/and strawberries on the roads.



We can characterise the forest with special formulas where:

- **A** means "*For all roads in the forest*"
- **E** means "*There exists at least one road in the forest*"
- **G** means "*There will always be, on each road section*"
- **F** means "*There will be at least one, on some road section*"

For example: "**AG** (Mushroom **AND** Strawberry)" means that "*For all roads in the forest, there will always be Mushroom and Strawberry on each road section*".

Which of the following formulas is correct for the given forest?

A) AF (*Strawberry*)
B) AG (*Strawberry* **OR** *Mushroom*)
C) EG (*Strawberry* **OR** *Mushroom*)
D) EG (*Strawberry*)

It's informatics!
Propositional logic is very important for using in computer science to express e. g. results of comparing or properties to analyse models, using formal-based techniques, or verify of theorems. We can use a data type named Boolean (with its value true/false or 0/1) in some programming languages for work with propositional logic.

Keywords
Temporal logic
Graphs
Concurrent systems

T27: Rectangles

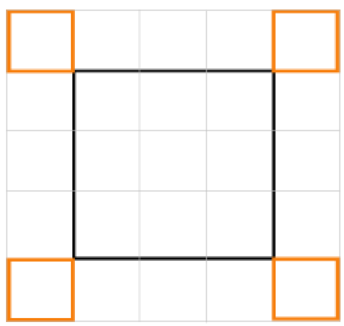
A small robot is specialized in drawing rectangles. These are the **commands** it can execute.

Orange	Draw an orange line of length 1 unit
Black	Draw a black line of length 1 unit
Turn	Turn 90 degrees to the right

These are the **rules** the robot can follow.

A , B	do A followed by B
n x B	do B n times
n x (...)	execute the commands within the brackets n times.

The robot wants to draw the image shown here in orange and black. It is given four possible sets of instructions to follow. However one of them will not lead to a drawing of the correct shape.



Which one of these sets of instructions is WRONG?

A) 4 x (2 x (Orange , Turn) , Orange , 3 x Black , Orange , Turn)
B) 4 x (3 x Black , 3 x (Orange , Turn) , Orange)
C) 4 x (2 x (Orange , Turn) , 3 x Black , 2 x (Orange , Turn))
D) 4 x (Black , 3 x (Orange , Turn) , Orange , 2 x Black)

It's informatics!

The program of the robot is a so-called algorithm, in other words a sequence of commands. It describes how a problem (here the drawing of the figure) is solved by decomposing the problem into many small individual steps.

These individual steps are repeatedly executed when needed (here, for example, 3 x Black to draw the long black line).

If the right commands are in the correct order, we have a program that solves the problem.

Keywords

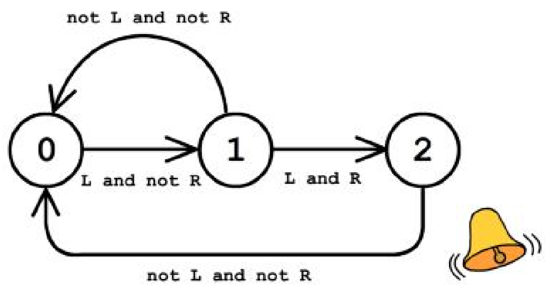
Algorithm

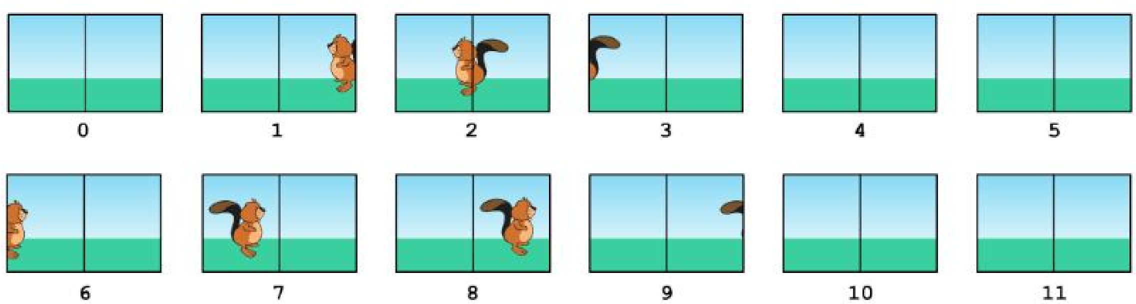
T28: Motion Detection

At the market there is a camera connected to a computer that rings a bell, when certain movements in the observed area take place. The computer evaluates the live camera image every second. It detects a movement by comparing the present image with the image a second before.

The computer can be in three different states and works according to the diagram. At the beginning it is in state 0. The arrows and annotations describe, when the computer changes from one state to another. The computer rings the bell, when it goes from state 2 back to state 0.

L = The left half of the image has changed.
R = The right half of the image has changed.





At the beginning the computer is in state 0. When does the bell ring?

A) Between 10 and 11
B) Between 9 and 10
C) Between 2 and 3
D) Between 3 and 4

It's informatics!

In security relevant areas (like airports) there are observation cameras. The live image of these cameras is evaluated by computers in order to count the number of persons entering an area or to detect dangerous situations. Evaluation programs are based on state transition diagrams like in this task.

Keywords

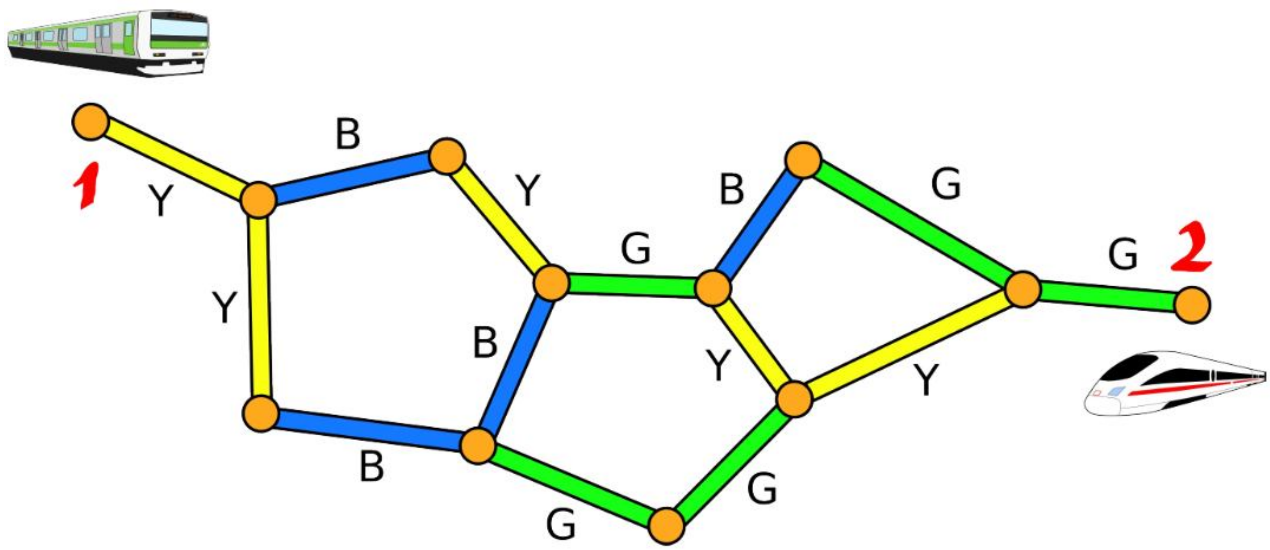
Observation camera
State transition diagram

T29: Express trains

Two trains are going towards each other starting from stations 1 and 2. The map below shows all the stations and coloured rail tracks between them.

At every moment, one of the trains is moving, and the other stays at some station. While a train moves, the colour of the rail track it is passing is recorded. Unfortunately, the record does not store which of the trains was moving.

For example, the record **BG** can either mean that one of the trains passed over a **B**lue and then a **G**reen rail track, or mean that at first, some train passed over a **B**lue rail track, and then the other passed over a **G**reen rail track.



The two trains finally met. Which of the following records was stored up to the moment of meeting?

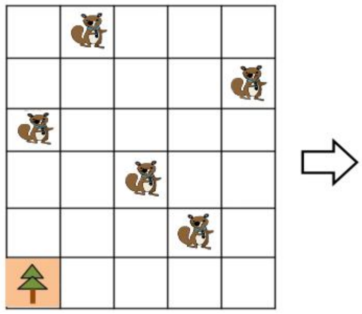
A) GYGBGYBB
B) YYBYGGBG
C) GBYBYGY
D) YBBYBYY

It's informatics!
If two independent processes are running in a processor it is necessary to manage which of them precedes because processor can realize only one process in the moment. It reminds us our two trains of which only one is allowed to move.

Keywords
Graphs
Distribution of computing

T30: Summed Area Table

A colony of beavers lives in a rectangular wetland, which is divided into a 6x5 grid as shown on the left map below.



1	2	3	4	5
1	1	2	3	4
1	1	2	3	3
0	0	1	2	2
0	0	0	1	1
0	0	0	0	0

One big tree that is located at the bottom left corner of the map is used a reference point. In order to keep each beaver's home a secret from other animals, the beavers decided to encrypt their map. They put an integer in each grid of the encrypted map (a 6x5 table). The last year map is shown above on the right. Figure out how the encryption works.

The encrypted map of this year looks like the table below:

1	3	4	7	9
1	3	**4**	**6**	**8**
1	2	**3**	**5**	**6**
1	2	**3**	**4**	**5**
0	1	1	2	3
0	0	0	0	1

How many beavers are living in the bold rectangle region?

A) 5 **B)** 4 **C)** 3 **D)** 2

It's informatics!

A summed area table is an efficient data structure to calculate the sum of values in a rectangle subset of a grid. It has been used in several computer science applications, for example, in Haarlike features for object recognition.

Keywords

Summed area table
Integral image
Encryption

CORRECT ANSWERS

Task #	Answer	Task #	Answer	Task #	Answer
1.	**C**	11.	**A**	21.	**B**
2.	**C**	12.	**D**	22.	**B**
3.	**C**	13.	**B**	23.	**C**
4.	**C**	14.	**A**	24.	**B**
5.	**B**	15.	**A**	25.	**D**
6.	**B**	16.	**A**	26.	**C**
7.	**D**	17.	**C**	27.	**C**
8.	**C**	18.	**C**	28.	**A**
9.	**C**	19.	**C**	29.	**A**
10.	**A**	20.	**D**	30.	**C**