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Catalog of research topics offered to students as part of the ERASMUS+ MaSuD project from 2020 to 2023

MaSuD

The Mathematics for Sustainable Development

2020-1-FR01-KA229-079794

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List of topics offered to student volunteers in the ERASMUS+ MaSuD project. Students worked for one hour a week for a whole school year on their chosen topic.
For each topic, you'll find the text presenting the subject, the groups of different partners who worked on it, and the productions they produced at the end of the year.

Contents

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The CO2 emissions impact on the arrival of high-school students at school (2020-2021 n°1)

After a first phase of researching relevant criteria involving transporters and students, the students will have to develop a model of the carbon impact caused by the students coming to high school.

This model will be changed to measure the modifications that this may cause. Examples of modifications: optimization of the routes to high school, change of means of transport for some students.

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
	2 groups (5 students)	1 group (2 students)	1 group (2 students)

Productions : https://twinspace.etwinning.net/122026/pages/page/1636092

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How to count a population of wolves (2020-2021 n°3)

We imagine that in a packet of rice, some grains are green. Develop a pattern or process for counting these grains of rice (without going through them one by one).

Confront your approach with people in the field who have to count animal species.

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
1 group (3 students)		2 groups (6 students)	

Productions : https://twinspace.etwinning.net/122026/pages/page/1847215

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Optimization of the electricity consumption of an establishment (2020-2021 n°4)

With the help of the management and administration services, produce a model of the electricity consumption of an establishment at a certain time. Confront it with reality, taking into account the sunshine. Then once the model seems reliable, propose measures to be taken and give the economic consequences.

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
2 groups (5 students)		1 group (5 students)	1 group (4 students)

Productions : https://twinspace.etwinning.net/122026/pages/page/1847218

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A study of invasive species (2020-2021 n°5)

To model in a simple way the dispersion of the pampas grass, imagine a square garden, divided into nine identical plots. The reproduction of the plant is obviously made by its seeds, of which we will assume, for simplicity, that the fifth of seeds remain in place, the other four fifths being dispersed in equal parts on the adjacent plots. Develop the system by placing the starting point in one of the nine plots and in assuming the first plant provides 1 unit of seed at its first flowering.

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
3 groups (6 students)	3 groups (9 students)	1 group (1 student)	1 group (3 students)

Productions : https://twinspace.etwinning.net/122026/pages/page/1633858
Article : Article published by MATh.en.JEANS

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Building sustainable facilities has become a more and more discussed issue (2020-2021 n°6)

- How would you define a sustainable facility?
- In which proportion do you consider your home or school building sustainable?
- If you were part of a team of architects, how would you design a sustainable building?

(Sustainable refers to creating and maintaining conditions that balance the economic, social, and environmental requirements of present and future.)

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
	2 groups (8 students)		

Productions : https://twinspace.etwinning.net/122026/pages/page/1601802

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Modeling of plant growth (2020-2021 n°7)

Study tree leaves, flowers or snail shells to come up with a L-system model of evolution..

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
1 group (4 students)	1 group (3 students)		

Productions : https://twinspace.etwinning.net/122026/pages/page/1636101
Article : Article published by MATh.en.JEANS

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The volume of a tree (2020-2021 n°8)

Measure the volume and the "density" of a tree.
Note: The density has to be defined, for example, the volume of CO2 that can be absorbed, the maximum surface covered by the tree's shadow, the number of leaves (the green parts) compared to the volume of the tree.

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
1 group (2 students)	2 groups (6 students)	1 group (3 students)	

Productions : https://twinspace.etwinning.net/122026/pages/page/1636107
Poster : https://www.site.ac-aix-marseille.fr/lyc-valdedurance/spip/Productions-MATh-en-JEANS.html
Article : Article published by MATh.en.JEANS

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Solar panels (2020-2021 n°9)

Your school wants to put a maximum of solar panels on its roof to reduce its use of energy. Estimate the possible number of solar panels, taking into consideration the efficiency of the system for one year.

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
1 group (2 students)	2 groups (5 students)	1 group (5 students)	1 group (3 students)

Productions : https://www.mathenjeans.fr/sites/default/files/comptes-rendus/poster-solar_panels_final.pdf
https://twinspace.etwinning.net/files/collabspace/6/26/026/122026/files/c4958b80a.pdf

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Determine the day of exhaustion of the resources of your establishment (2020-2021 n°10)

Understand how the calculations are made. Measure the CO2 consumption of students once in the establishment and the green spaces that could absorb the CO2 to see from when, in the school year, the establishment will have exhausted its resources. Why not propose actions to push back this date.

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
		1 group (2 students)	1 group (2 students)

Productions : https://twinspace.etwinning.net/122026/pages/page/1601826

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Corridors and distancing (2020-2021 n°11)

We will model the movement of individuals between two rooms by means of a corridor. At the beginning, we prevent any collision, then we establish social distancing areas around each person. These areas must not intersect. Experiments will show that some corridor shapes or sizes are better suited than others. One possible application would consist in analysing the maximum social distancing allowed by the passage areas in your high school, without disturbing the flow of students.

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
1 group (4 students)	1 group (3 students)		1 group (3 students)

Productions : https://twinspace.etwinning.net/122026/pages/page/1635100
Poster : https://www.site.ac-aix-marseille.fr/lyc-valdedurance/spip/Productions-MATh-en-JEANS.html

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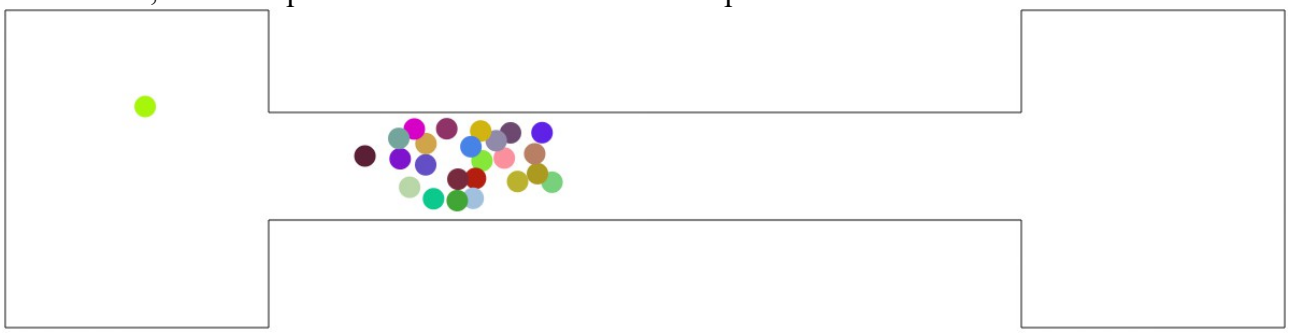
Impact of distancing (2021-2022 n°1)

Repeat subject 11 from last year, providing a "simulator" with different parameters: n number of pupils, d distancing distance, l length of corridor, L width of corridor.
The aim is to simulate the time taken for pupils to move from room A to room B and, from the simulations, to draw up a time law as a function of each parameter.



Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
			1 group (3 students)

Productions

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Percolation (2021-2022 n°2)

The soil is modelled by a grid of 100x50 cells with a certain density (d) of occupied cells (black). Water (blue) is on the top layer. It circulates in a cell if the latter is empty (white) and if it has a common side with a cell where there is water (blue cell). Note t the time (evolution number) for the water to pass through the soil. Using simulations, establish the law of t as a function of d.

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
1 group (3 students)	5 groups (16 students)		1 group (3 students)

Productions : https://twinspace.etwinning.net/122026/pages/page/2268093
Poster : https://www.site.ac-aix-marseille.fr/lyc-valdedurance/spip/Productions-MATh-en-JEANS.html

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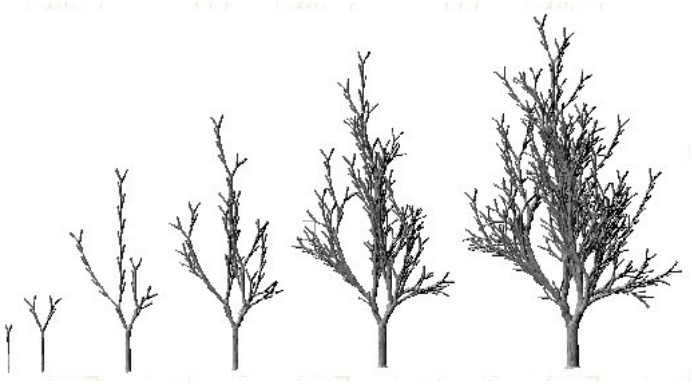
Modelling tree growth (2021-2022 n°3)



Consider a two-dimensional tree model with three types of elements A, B and C.
A trunk A can grow into A(45%), A[B+](20%), A[B-](20%), [B+][B-](15%).
A white B can evolve into B(45%), B[C+](20%), B[C-](20%), [C+][C-](15%)
A C branch can evolve into C(45%) stop (55%)
We start with a trunk A. Simulate and study the changes. Give the results for the height of the tree (number of A's), the number of branches (B and C) and the life of the tree (number of evolutions).

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
3 groups (6 students)	2 groups (6 students)		

Productions : https://twinspace.etwinning.net/122026/pages/page/2268120

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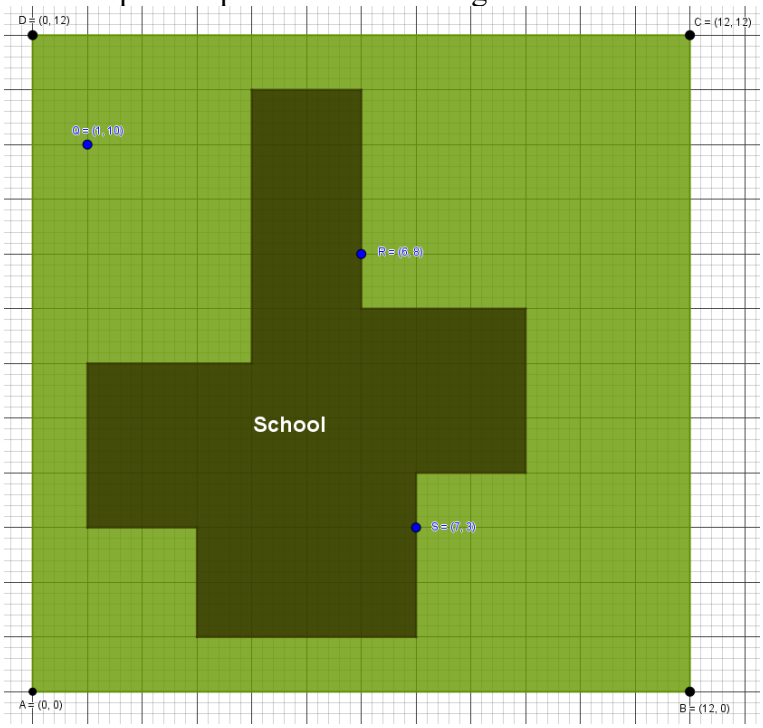
Watering the school (2021-2022 n°4)

Our school building has the following shape. There are three outside water taps (Q, R and S) on the ground floor for watering and in case of fire. Which area is closest to each tap and what is the greatest distance between a tap and a point on the building or the enclosure surrounding the school?



Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
2 groups (8 students)	3 groups (10 students)	2 groups (7 students)	1 groups (2 students)

Productions : https://twinspace.etwinning.net/122026/pages/page/2271630
Article : Article published by MATh.en.JEANS
Award : André Parent Prize 2023

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Distance between words (2021-2022 n°5)

How does my spellchecker suggest a list of words when I make a mistake in a word? You are asked to construct a distance between words, i.e. one that verifies d(A,B)=d(B,A) ; d(A,B)=0 if A=B, d(A,B)⩽d(A,C)+d(C,B)

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
		1 group (3 students)	1 group (2 students)

Productions : https://twinspace.etwinning.net/122026/pages/page/2371661

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A stochastic model for fish stock management (2021-2022 n°6)

In order to model the management of fish stocks, we consider the deterministic model of Schaefer (1954). For this, we take into account a variable M (in tonnes) which represents the maximum biomass that can live on a certain site and a variable r which represents an intrinsic growth rate (specific to the fish species).

If, for $n \geq 0$, we consider the variable Xn, which is the biomass in year n, then the model gives the biomass in year n+1 as

$$X_{n+1}=X_n + rX_n(1-X_n/M) - C$$

where C is the quantity of biomass harvested by the fishermen.

The initial quantity of biomass $X0$ is given by a measurement.
The question then arises:
Can we model all possible situations (extinction, equilibrium, uncontrolled growth of the species) by modifying the parameters (initial biomass, reproduction rate, annual quantity of fishing)?

We can also introduce environmental variability by considering a random variable Vn (which can, for example, take the 3 possible values 0.5, 1 and 1.5 and which represents the environmental variability for year n), and we introduce the model

$$X_{n+1}=(X_n + r X_n (1- X_n /M) - C) V_n$$

We can also propose a fishery proportional to the biomass present on a site, of the type $C=p\ Xn$ where p is the authorised fishing rate.
1) How can this fishing rate be chosen so as not to cause the species to disappear?
2) Is it possible to choose an optimum fishing rate?

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
1 group (4 students)	2 groups (7 students)	2 groups (6 students)	

Productions : https://twinspace.etwinning.net/122026/pages/page/2271681
Article : Article published on the MATh.en.JEANS website

Article published on the MATh.en.JEANS website

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Shape of the dunes (2021-2022 n°7)

Place a polygonal shape (triangle, square, rectangle, L-shape) on a support. Sand is dropped. How will the crest lines of the pile of sand be positioned?

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
1 group (4 students)	2 groups (6 students)		

Productions : https://twinspace.etwinning.net/122026/pages/page/2271805
Article : Article published on the MATh.en.JEANS website

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Environmental Dobble (2021-2022 n°8)

Dobble consists of 55 cards with 8 symbols on them. Whichever way you play (there are several possible rules), the aim is always to find a common symbol between two cards as quickly as possible. In fact, two Dobble cards always have one and only one symbol in common, as in the example below:

How is the game constructed? How many symbols are needed to make a 10-card deck? Or conversely, how many cards are needed to make a 10-symbol game? Can you make a Dobble game with symbols linked to the environment? Find a relationship between the number of cards and the number of pictures. How does this relationship change if two cards have two, three, etc. images in common?

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
3 groups (12 students)	3 groups (10 students)	3 groups (12 students)	1 group (3 students)

Productions : https://twinspace.etwinning.net/122026/pages/page/2273426
Article : Article published on the MATh.en.JEANS website

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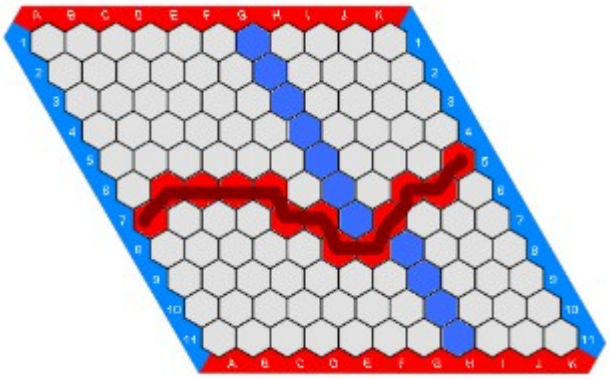
The game of Hex (2021-2022 n°9)



Hex is played on a diamond-shaped board with hexagonal squares. There is one blue player and one red player. Each player, in turn, colours a square of the board with their own colour. The aim of the game for the red player is to link the two red sides of the board by a path made up of red squares, and vice versa for the blue player. Set up a winning strategy.

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
1 group (3 students)		1 group (2 students)	1 group (4 students)

Productions : https://twinspace.etwinning.net/122026/pages/page/2371663
Posters : poster_finale_hex.pdf (ac-aix-marseille.fr)

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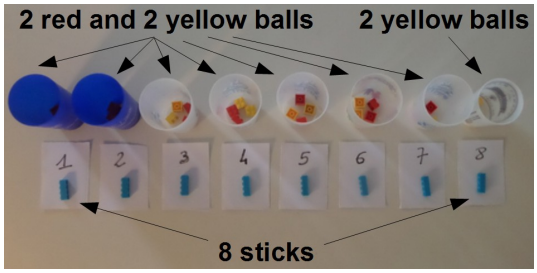
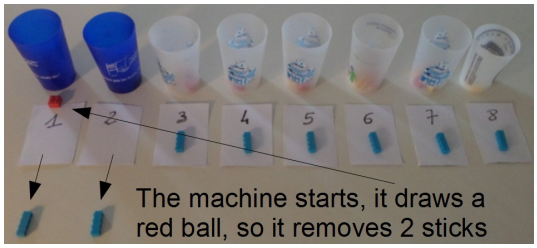
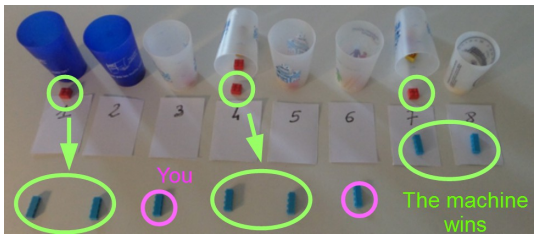
The machine to play the sticks game (n°1 2022-2023)

The game of sticks is simple: two players play with 8 sticks, each in turn removing one or two sticks, the one who takes the last one wins.
We have a machine with 8 cups numbered from 1 to 8. We initialise the machine with two balls of each colour (yellow/red) in each cup except in cup 1 with only two yellow balls.
We suggest you play several games against a machine as follows:
- The machine starts.
- When it is the machine's turn to play, it draws a ball at random from the cup corresponding to the number of sticks left in the game. If the cup is empty, two yellow and two red balls are placed in the cup (except in cup n°1, where only two yellow balls are placed).
- If the drawn ball is yellow it removes one stick, otherwise two.
- The drawn balls are placed in front of the corresponding cup.

At the end of a game, if the machine has won, it is "rewarded" by putting the played balls back into the corresponding cups and for each ball that is put back, a ball of the same colour is added to the cup. If the machine loses, it is "punished" by removing the balls it has played.
On average, how many games does it take for the machine to always win?
How do you "program" a new machine if you change some of the parameters of the game: number of sticks, number of sticks you can remove (not necessarily consecutive numbers).







Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
5 groups (20 students)	2 groups (6 students)	1 group (3 students)	

Productions : https://padlet.com/proalh/1-the-machine-to-play-the-sticks-game-isd27i55rpj2tlf8
Award : Strategy prize at the "Faites de la science 2023" qualifiers
Award : Honorable mention for the University of Suceava at the National Olympiad for Scientific Creativity, 2023 edition

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Weaving loom (2022-2023 n°2 & 3)

Strips of A4 paper are cut out (e.g. with a paper cutter) to obtain strips of identical width. With these strips of paper, we can weave (without glue).
Study the different types of braiding possible and make a 5cm strip as long as you want. Try to make strips, bags, hats or curtains with the used A4 sheets you have collected in your school.

Choose your own way of weaving and try to build a "machine" that can make it with paper strips.

Partners

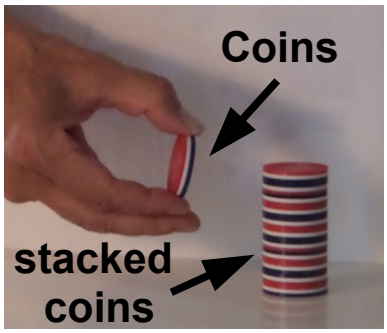
Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
2 groups (5 students)	2 groups (7 students)	1 group (2 students)	

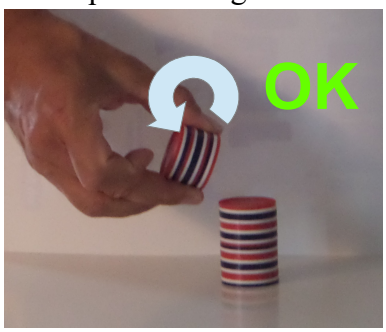
Productions : https://padlet.com/proalh/3-weaving-loom-iv49nkr21vku7x98

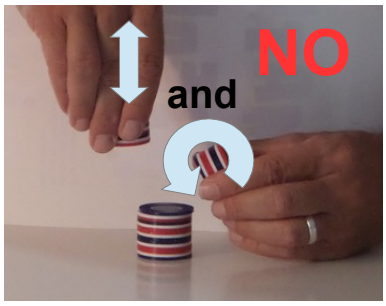
Funded by the European Union

Turning over coins (n°5 2022-2023)

We have a certain number of stacked coins. A stack of coins can be turned over partly, but only by starting from the top of the stack. How many times do you have to repeat this operation to get all the coins on the front side? How should we proceed in general?







Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
2 groups (11 students)	4 groups (13 students)	1 group (3 students)	1 group (2 students)

Productions : https://padlet.com/proalh/5-turning-over-coins-txojjc60gtfmglu3

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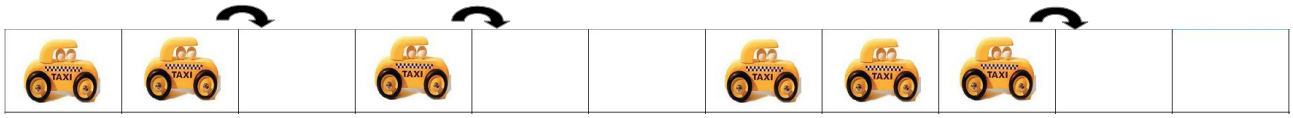
Traffic jams (2022-2023 n°6)

In order to simplify the problem of traffic jams, let's start with a simple case:
- a single line of cars
- the cars are all identical and move at the same speed
- two possible positions: stop or go
- a car moves forward one square when the space in front of it is empty
- a car stays in place when the space in front of it is occupied.



We place a number of cars on our road, to study the evolution of the traffic.

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
2 groups (9 students)	4 groups (11 students)	1 group (2 students)	3 groups (8 students)

Productions : https://padlet.com/hubertproal/6-traffic-jams-mxrqw3gra3iw9he4

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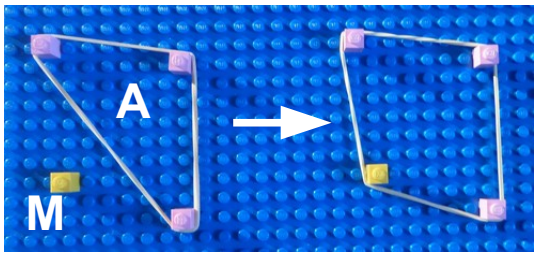
Inflated sets (2022-2023 n°7)

We take a convex plane figure. The diameter of the figure is the greatest distance between two points of this figure. To this figure (A) we can "add" a point M outside the figure by considering the convex envelope formed by A and M. It is like placing a rubber band around A and M.



A figure is said to be "inflated" when the addition of any point in the plane (in the above sense) increases its diameter.
Try inflating a square and other shapes. What can be said about inflated figures of the same diameter?

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
2 groups (5 students)	5 groups (12 students)	1 group (2 students)	2 groups (4 students)

Productions : https://padlet.com/hubertproal/7-inflated-sets-rmz2kgtpgi2p8m0v

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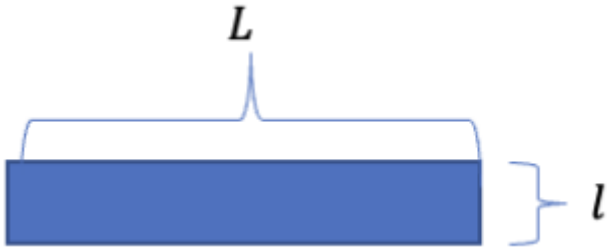
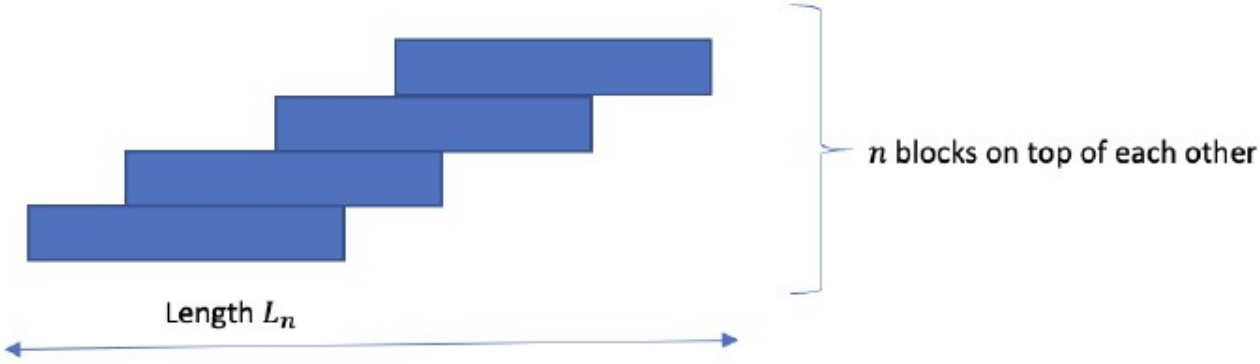
The largest building (2022-2023 n°8)

Suppose we have at our disposal building blocks of rectangular parallelipipedic shapes and of dimensions $L = 60$ cm and $l = 20$ cm and some depth $h = 10$ cm.



Can we place many of these blocks, on a planar floor, on top of each other without them collapsing such that the length Ln of this construction is 10 meters long horizontally?



If yes, how many pieces do we need for this? Is it possible to achieve a length Ln of 100 meters without the blocks collapsing? What is the minimal number of pieces n necessary for such a construction? What would be the vertical height of such constructions? Can you explore similar questions for building blocks of different shapes?

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
4 groups (23 students)	3 groups (9 students)		2 groups (4 students)

Productions : https://padlet.com/hubertproal/8-the-largest-building-2zfp54dbkemsovbx

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Evolution of parasites (n°9 2022-2023)

In an isolated environment, we study the relation between a certain type of parasite and their host and how these evolve with time t (continuous or discrete). In our model, parasites deposit eggs on their hosts and when the eggs hatch, the host dies. Denote by H and P the number of hosts and parasites respectively (these can be modelled as a function of t). At each step (unit time), the number of eggs deposited depend on the probability that a parasite and a host meet. One can assume that this probability is proportional to the product $H.P$ of the populations.
We are given fixed values b and d for the birth and death rate of hosts when no parasites are present. Moreover, we let dp be the death rate of the parasites.
Run simulations for given values of b, d and dp and try to determine what happens with the populations H and P in time.

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
	3 groups (7 students)	2 groups (8 students)	2 groups (7 students)

Productions : https://padlet.com/hubertproal/9-evolution-of-parasites-jqwrajzcwdxwivzx

Funded by
the European Union

Bacteria attacks (2022-2023 n°10)

In a bacterial culture, some of the bacteria are producing a toxic substance that kills bacteria. The number $N(t)$ of bacteria organisms increases at each time unit in a way that is proportional to the existing population at any time and decreases at a rate proportional (per organism) to the concentration of the toxic substance. One can (but don't have to) assume that the change in population of bacteria is of the form

$$k \cdot N(t) \cdot (1 - a \cdot T_x(t))$$

where k, a are some fixed parameters and $T_x(t)$ is the concentration of toxic substance. Suppose the toxic substance is formed at a constant rate r per organism, hence the change in the concentration of toxic substance is of the form $r \cdot N(t)$

Perform experiments to analyse the evolution of the population $N(t)$ with time, for some given initial population N_0, and fixed parameters k, a, r.

Computer implementations of these simulations would be very interesting.

Partners

Pertuis (FR)	Cluj (RO)	Alès (FR)	Satu-Mare (RO)
	3 groups (9 students)	2 groups (7 students)	

Productions : https://padlet.com/hubertproal/10-bacteria-attacks-lolpgt1l52bi5lc8