August 20-30, 2012
Lyon, France

INTERNATIONAL SUMMER SCHOOL OF MATHEMATICS FOR YOUNG STUDENTS

Welcome booklet

ISSMYS International Summer School of Mathematics for Young Students
2nd edition
Lyon, August 20-30, 2012

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2.1 Committees

The preparation of the summer school was only possible through the combined effort of the different committees. The Scientific Committee was responsible for the scientific content of ISSMYS 2012. It prepared the final list of conference topics and invited speakers. The Organizing Committee was responsible of all general aspects of the organization. The Local Organizing Committee (LOC) was there to help the Organizing Committee for functional organization of ISSMYS 2012, including the selection of the most suitable locations, preparation of the Internet site, arrangement of the social program, coordinating the contact with invited speakers, participants, sponsors.

Scientific Committee :

- Dierk Schleicher (chair)
- Martin Andler
- Etienne Ghys
- Frances Kirwan
- Alexey Sossinsky
- Marta Sanz-Solé
- Serge Tabachnikov
- Anatolij Vershik
- Karen Vogtmann
- Wendelin Werner
- Jean-Christophe Yoccoz
- Don Zagier
- Günter Ziegler

Organizing Committee :

- Étienne Ghys (chair)
- Martin Andler
- Jim Carlson
- Olivier Druet
- Victor Kleptsyn
- Nicolas Pelay
- Nathalie Revol
- Dierk Schleicher
- Sergei Tabachnikov

Local Organizing Committee:

- Nicolas Pelay (chair)
- Guillaume Aupy
- Etienne Ghys
- Richard Griffon
- Damien Lucas
- Christian Mercat
- Laura Pallez
- Élodie Pozzi
- Michele Triestino

2.2 Presentation of the Organizers

Martin Andler teaches mathematics at the University of Versailles Saint-Quentin; he has held visiting positions at MIT and Rutgers University. His research focuses on two main areas: representation theory of Lie groups, and the history of 20th century mathematics. He is the chairman of Animath, a French organization promoting mathematics for kids.

Jim Carlson is the president of the Clay Mathematics Institute. He is a professor emeritus of the University of Utah.

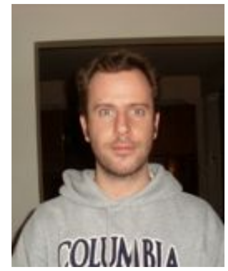
Olivier Druet is a researcher in the CNRS (National Center of Scientific Research). He works in the ENS of Lyon, and he's interested in non-linear analysis on manifolds, partial differential equations and Riemannian geometry.

Étienne Ghys (chair of CO) is a French mathematician. His research focuses mainly on geometry and dynamical systems. He also expresses much interest in the historical development of mathematical ideas, especially the contribution of Henri Poincaré. He co-authored the computer graphics mathematical movie Dimensions: A walk through mathematics. He is is currently a CNRS "directeur de recherche" at the École normale supérieure in Lyon. He is also a member of the French Academy of Sciences.

Richard Griffon is a PhD student at Paris 7 University. His favorite mathematical activity is (to try) to decipher the mysterious blend of number theory and algebraic geometry encoded in an L-function. Outside the lab, he loves reading, drawing and taking pictures: in particular, he made the poster for ISSMYS 2012. He is a thrilled member of “Plaisir Maths”.

Victor Kleptsyn is a researcher at CNRS, in the Institute of Mathematical Research of Rennes. His working themes are mainly dynamical systems and geometry. His belief is that most arguments, theorems, and proofs in the mathematics should be visual, and easily explicable, at least on the “why should it be true” level of explanation.

Damien Lucas has long worked for an organization that creates scientific holidays, and himself led young people from 6 to 18 years as a leader and director of summer camp in France but also abroad. He loves games and remains to this day still unbeatable in Othello. He has taught mathematics workshops in primary schools and is a founding member of the association "Plaisir Maths".



Christian Mercat is the director of the Institute for Research on Math Teaching (IREM) in Lyon. His field of expertise is discrete geometry, especially discrete Riemann surfaces, and its links to integrable models. He is a member of S2HEP, IUFM and UCB Lyon 1.

Laura Pallez is a student in mathematics' teacher science in Lyon, she wants to continue in this field and become a researcher. She is mainly interested in mathematics and games, and wants to make every pupil discover the fun which is inside mathematics. She is an active member of the association "Plaisir Maths".

Nicolas Pelay (chair of LOC) is a research professor in Paris 7. After an engineering degree in mathematics and computer science and a PhD thesis in didactic of mathematics, he is a founding member and the president of the association "Plaisir Maths". He is a devout advocate of the diffusion of math.

Élodie Pozzi is a postdoctoral fellow at Inria Sophia-Antipolis. Her resarch focuses in functional analysis and approximation theory. She is involved in various activities related to the diffusion of mathematics and also in promoting the participation of women in math studies.

Nathalie Revol has been educated in France in computer science and applied mathematics. She has been an associate professor at the University of Lille and she is now a research scientist at INRIA. Her main research topic is computer arithmetic, and in particular interval arithmetic and its variants. Her viewpoints range from the mathematical theory to the implementation on computers, including standardization issues, links with verified numerical computations, formal proofs.

Dierk Schleicher is a professor of mathematics at Jacobs University Bremen. He obtained his PhD at Cornell University, NY, and held visiting positions in Berkeley, Stony Brook, Paris, Toronto, and München. His main research interests are in dynamical systems and chaos, especially in holomorphic dynamics and the Mandelbrot set, and the dynamics of Newton's root-finding method. He was one of the main organizers of the 50th International Mathematical Olympiad (IMO) 2009 in Bremen.

Michele Triestino is currently an emigrate Italian mathematician in the wonderful place which the ÉNS of Lyon is. He is trying to mix together some probability, dynamics and geometry on the circle in order to work out a PhD thesis. Usually, he attempts to reach mathematical summer schools by bike: this time it will be not so difficult!

Sergei Tabachnikov is a professor of mathematics at Penn State University. He works in geometry, topology, and dynamics - one of his favorite topics is mathematical billiards. He also likes to combine theoretical research with computer experiments. He (co)authored several books including "Mathematical Omnibus", a collection of 30 lectures on classic mathematics. Sergei is the Director of the semester-long MASS (Mathematics Advanced Study Semesters) Program at Penn State.

Guillaume Aupy is a PhD student in theoretical computer science at the ENS of Lyon. His work focuses on various aspects of scheduling, with different constraints such as the energy consumption or the reliability. Outside the lab, he loves TV shows, mangas and camping.

3 Scientific Program

3.1 Lecturers

Marie-Claude Arnaud is a French mathematician working on Hamiltonian dynamics. She made important contributions in the theory of dynamical systems, most specifically in billiards and in the world of C^1-regularity. At present, she is a professor at the university of Avignon (France).

Vincent Beffara is a French mathematician working on Probability Theory. He is one of the biggest experts in SLE processes and Percolation Theory, whose interests go the world of conformal mappings to Statistical Physics. He is currently a researcher at the ENS of Lyon.

Bob Connelly is a mathematician specializing in discrete geometry and rigidity theory. He is best known for discovering embedded flexible polyhedra. One such polyhedron is in the National Museum of American History. He is currently a professor at Cornell University. His recent interests include tensegrities and carpenter's ruler problem which can be resumed as this: *Can a simple planar polygon be moved continuously to a position where all its vertices are in convex position, so that the edge lengths and simplicity are preserved along the way?*

John H. Conway is one of the most prolific mathematicians. He is probably best known for the *Game of Life*, which he invented, as well as for *combinatorial game theory* that he developed (partly in collaboration): a very natural and simple definition that lead to a class of games with incredibly rich structure, containing the now-famous *surreal numbers*. He has made substantial contributions to many other areas of mathematics, for instance group theory. He greatly enjoys spending time and discussing with students.

Christophe Garban is a researcher at CNRS in the department of mathematics of ENS Lyon (UMPA). His research focuses on Probability Theory and more precisely on the study of the fractal pictures which appear at the phase transition of statistical physics models. Surprisingly, some of the tools used to study these phase transitions are borrowed from theoretical computer science (such as the harmonic analysis of Boolean functions).

Matthias Kreck is a German mathematician who works in the areas of algebraic topology and differential topology. He gave great contributions in the understanding of smooth manifolds. He is currently professor at the university of Bonn. He plays cello in his spare time.

Yves Meyer, Professor Emeritus at École Normale Supérieure de Cachan, is a French mathematician. He gave fundamental contributions to number theory, operator theory and harmonic analysis. He played a leading role in the modern development of wavelet theory, which has had a spectacular impact in information sciences, statistics and technology. In 2010, he was awarded the Gauss Prize.

Ken Ono is an American mathematician, specializing in number theory. He is an Asa Griggs Candler Professor of Mathematics and Computer Science at Emory University. He is actively involved in the mentoring young mathematicians of all ages.
He spends much of his spare time outdoors and with his family. He enjoys surfing, SCUBA diving, cycling, running, and swimming. He has been selected to represent the United States in the 2012 ITU World Cross Triathlon Championship in May.

Valentin Ovsienko is a Russian mathematician working in France. He received the PhD degree from the Moscow University and he is currently a researcher at the University of Lyon. His research interests include many domains of algebra, differential geometry, and mathematical physics. Valentin believes that some day mathematics will be unified again, as it was in the good old days.

Gaiane Panina is a professor at the St. Petersburg State University. Her research interests are: convex polytopes, combinatorial geometry, polygonal linkages, all illustrated, like here: `http://www.eg-models.de/models/Surfaces/2010.02.002/_direct_link.html` She particularly enjoys participating in student schools, both lecturing herself and attending classes given by her colleagues.

Laure Saint-Raymond is a French mathematician, professor in Paris. Her work concerns applied mathematics, more precisely fluid mechanics: she gave a fundamental contribution on the 6th Hilbert's problem about fluid limits. She is currently adjoint director at the department of mathematics at the Ecole Normale Supérieure.

Alexandre Shen works as a researcher in Montpellier (LIRMM, CNRS & University of Montepellier, France) and Moscow (on leave from Institute of information transmission problems, Moscow, Russia); his research topic is algoritmic information theory (Kolmogorov complexity) and algorithmic randomness (foundations of probability theory). Since 1981 he participates in the organization of Kolmogorov seminar in Moscow Univesity (started by Andrei N. Kolmogorov himself).
For many years he worked in advanced math program in Moscow teaching mathematics and computer science and wrote some books for high school students: *Algebra* (with Israel M. Gelfand), *Algorithms and Programs: Problems and Solutions* and several others (not translated into English).

Ken Stephenson is an American mathematician, researching and teaching at the University of Tennessee, Knoxville. Coming from the world of complex function theory, he was largely influenced by Bill Thurston's pioneering work on circle packings: his work culminated in his 2005 book *Introduction to circle packing: the theory of discrete analytic functions* and his software *CirclePack*. This is a new type of experimentally driven mathematics, and his principal goal now is promoting circle packing and its applications.

Tadashi Tokieda was born in Japan and educated in France, he obtained his PhD at Princeton University; he works at the University of Cambridge. He is interested in physics, particularly related to toys. Scholar and polyglot (in addition to Japanese, French, and English, he knows Greek, Latin, classical Chinese, Finnish, Spanish, and Russian), Tadashi is specialized in the popularization of mathematics and physics and is an outstanding communicator.

Cédric Villani is a French mathematician working primarily on the theory of partial differential equations involved in statistical mechanics, specifically the Boltzmann and Vlasov equations. He has worked on the theory of optimal transport and its applications to differential geometry. He is currently the director of Institut Henri Poincaré in Paris and Professor at the University of Lyon. He was awarded the Fields Medal in 2010.

Shmuel Weinberger is an American mathematician. His research interests include geometric topology, differential geometry, geometric group theory, and, in recent years, applications of topology in other disciplines. He has written a book on topologically stratified spaces and one on the application of mathematical logic to geometry. He irregularly keeps a blog on which you can read *I am a math professor at University of Chicago. I mainly work in geometry and topology, but I am curious about all sorts of things. I think of myself as an optimist, but many others do not.*

Jean-Christophe Yoccoz is a French Mathematician currently at the College de France. His works have given fundamental contributions in the theory of dynamical systems. He is an excellent chess player and he occasionally spends half a day on mathematical "experiments", by hand or by computer. He was awarded the Fields Medal in 1994.

Don Zagier is an American mathematician whose main area of work is number theory. In 1976, aged only 24, he became Germany's youngest professor. Among many other things, he is known for discovering a short and elementary proof of Fermat's theorem on sums of two squares: it consists of a single sentence. He is currently one of the directors of the Max Planck Institute for Mathematics in Bonn, Germany, and a professor at the Collège de France in Paris, France.

3.2 Summary of Presentations

When the Earth was too young for Darwin
by *Cédric Villani*, Monday 20^{th}

The age of the Earth has been a much debated subject for hundreds of years, and especially at the end of the nineteenth century, when the mathematics-based theories which were prevailing among physicists were in open conflict with evolutionary theories. Through this story we shall think about the status of mathematics in interaction with other sciences.

Jammed packings in the plane
by *Robert Connelly*, Tuesday 21^{th}

If you have ever driven behind a truck carrying a load of pipes, you might wonder if they if they were secured safely. You should. There are ways to do it that are stable, and ways that are not, and the distinction can be fuzzy. The pipes are essentially packings of circular disks in a planar box. The most dense packing of an infinite number of equal disks in the plane is known. But for pipes and granular materials it is enough that packing be the most dense only for small perturbations of the arrangement. The property of being rigid means that the the packing is jammed, and whether a packing is jammed can be calculated for reasonable containers.

Many interesting containers for circle packings are not boxes but tori, what you get by identifying the left and right sides, and the top and bottom, of a box in the plane so the boundary effects are avoided. There are interesting examples of jammed and not jammed packings of a finite number of circular disks in a torus that have been found by groups of undergraduate students at Cornell and Grand Valley University in Michigan. Their results will be presented.

TAs: *Rémi Boutonnet, François Le Maitre, Hsueh-Yung Lin.*

Codes, arithmetic and manifolds
by *Matthias Kreck*, Tuesday 21^{th}

I will explain the problem behind codes. When sending and receiving information, errors can happen. One wants to reconstruct the original information from the received. This leads to the concept of error correcting codes. This is so simple that one wonders why not everything is known. To indicate that this is completely wrong I will explain a relation between codes and unimodular lattices, which lead to very difficult problems in analysis. On the way very important lattices like E_8 or the leech lattice will occur. If time permits I will explain how codes occur in a very natural way in topology from manifolds with a bit symmetry. This leads to a new construction of codes, which I will explain.

TAs: *Adriane Kaïchouh, Thomas Letendre, Marielle Simon.*

Invitation to simple modeling of complex phenomena
by *Tadashi Tokieda*, Tuesday 21^{th}, Wednesday 22^{nd} and Thursday 23^{rd}

Drop a stone into water. It makes a sound, “glop” for a big stone, “splitch” for a small stone. Can you predict the pitch of the sound from the size of the stone?

The usual teaching of mathematical theories is like a pyramid.

Young people tend to become passive (if passionate) admirers of a structure built by old people, and problems they are taught to solve make them walk straight up to the peak. But what if we want to explore a natural mountain range, whose peaks are invisible among clouds, whose trails among trees are unknown?

The problem of the sound of a stone falling into water is natural, so natural that every child knows the phenomenon and can wonder about it. The mathematics involved is extremely hard, so hard that it is not taught at any mathematics department in the world.

This course tries to teach how to make *some* progress on *any* natural problem, when we know *nothing*. We will use no theory more sophisticated than calculus[1], which to a passive admirer may seem little, but the *way* we use it is very robust and powerful and a bit magical, and allows us to solve for example the problem above. In short, we shall learn the first steps in "applied mathematics".
TAs: *Sylvain Courte, Vincent Tassion, Greg Zitelli.*

Tensegrities: structures made with cables and struts – Why do they hold up?
by *Robert Connelly*, Wednesday 22^{nd}

Imagine a heavy object suspended by cables in midair. Imagine several objects suspended by cables yet so that the whole structure is completely stable. This is a tensegrity, a word suggesting "tensional integrity" by R. Buckminster Fuller after having been shown some models by the artist Kenneth Snelson in the 1940's. They seem to defy gravity, and yet examples of them are all around us as bridges, bicycle wheels, tents, spider webs, cloths lines, atoms, pebbles in a box, as well as works of art by Kenneth Snelson himself. What principles explain their stability? Where is the geometry? What is a good a geometric model?

A very natural way to do this is to think of a tensegrity as a collection of points, where some pairs, the cables, are not allowed to get further apart, while others, the struts, are not allowed to get closer together. If these conditions determine the configuration of points up to rigid motions of the whole configuration, then the tensegrity is rigid. The secrete to this rigidity is energy. Indeed, you can even invent your own special seemingly unrealistic energy that explains the geometric rigidity, while in the end it is quite consistent with actual physical properties of the materials themselves. Geometry and Physics live together in harmony.
TAs: *Rémi Boutonnet, François Le Maitre, Hsueh-Yung Lin.*

Flows and walks on graphs
by *Shmuel Weinberger*, Tuesday 22^{nd}

Suppose that a bacterium splits in two with probability 1/2 or otherwise dies, and we start with a small colony of 1000 bacteria. Can we expect to obtain an immortal colony? If I randomly walk on a line from a position one unit from my home, and I go in each direction with equal probability, how long will it take me to get home? What about in higher dimensional space? Is it possible to rearrange the assets of the points of a graph through trade among neighbors so that all profit?

These are among the problems that I will explain and interrelate in this introduction to the geometric/probabilistic side of graphs.
TAs: *Richard Griffon, Simon Iosti, Christelle Vincent.*

Combinatorics and Number Theory
by *Ken Ono*, Thursday 23^{rd} and Friday 24^{th}

Combinatorics and Number Theory are old mathematical subjects which are home to many simple to state open problems. This course will be a brief introduction to classical problems in combinatorics and number theory which quickly lead to the theory of modular forms. We shall discuss classical problems involving right triangles, partitions of integers, and the distribution of primes. The selected problems will highlight some of the deeper phenomenon which underneath seemingly innocent questions.
TAs: *Rémi Boutonnet, François Le Maitre, Valentin Hernandez.*

[1] Experience up to having seen simple differential equations (e.g. $y'' + ay' + by = 0$) solved, and common sense in mechanics, are desirable prerequisites.

Polytope algebra
by *Gaiane Panina*, Friday 24^{th} and Sunday 26^{th}

We will gradually build up a beautiful algebraic object based on purely geometric objects – the polytope (graded) algebra developed by Peter McMullen.

That is, we will introduce addition, multiplication, and even such crazy things as exponent and logarithm for polytopes.

This construction has helped to prove the f-vector problem (I will try to hint how) and is directly related to the Chow rings of algebraic toric varieties (this is beyond our course).

Surprisingly, there are no prerequisites. However, it is nice if you know what an Abelian (that is, commutative) group, a ring, and the (graded) algebra of polynomials are.
TAs: *Guillaume Aupy, Adriane Kaïchouh, Thomas Letendre.*

Circle Packing and Spontaneous Geometry
by *Ken Stephenson*, Friday 24^{th}

The topic of *circle packing* is about configurations of circles having specified patterns of tangency. You can specify how many circles you want and which of them are tangent to which others, and then – quite amazingly – find radii and centers for the circles so that they fit together in exactly the desired pattern!

Note that the pattern is combinatorial information, specified via a graph. The circles do an involved dance, adjusting radii until each can fit with its prescribed neighbors, and when they have finished, their layout gives us geometric information. This is "spontaneous" in that each circle worries only about itself and its immediate neighbors, yet the resulting configuration has rigid global consequences. The connection between combinatorics and packing geometry is what we will study. Fortunately, the software *CirclePack* does the work of computing and displaying the results, providing an open experimental platform for investigating this fascinating interplay between combinatorics and geometry.
TAs: *Alessandro Carderi, Mikhail Hlushchanka, Michele Triestino.*

From complex numbers to quaternions and beyond
by *Valentin Ovsienko*, Sunday 26^{th}

Algebra? Geometry? Number theory?

Let us call this subject simply: Mathematics. The main goal of these lectures is to explain why do mathematicians invent "complicated" algebraic structures. Our main character will be the algebra of quaternions. Invented by Sir William Hamilton in 1843, quaternions extend complex numbers. But, unlike usual numbers, the algebra of quaternions is non-commutative that makes it more complicated.

Non-commutative? Are we sure? We will see that the algebra of quaternions is, in fact, commutative if we understand what the commutativity really means.
TAs: *Khudoyor Mamayusupov, Marielle Simon, Greg Zitelli.*

Billiards
by *Marie-Claude Arnaud*, Monday 27^{th}

You play billiard in a smooth and strictly convex table... which kinds of trajectories will you observe?

We will explain:

- Why mathematicians began to look at this problem?
- How to model this? In particular, we will see that the billiard map can be seen as a map of a (bounded) cylinder.
- How to find trajectories? We will see that a lot of orbits are maximizers of a certain function and that this function is the length of the trajectory.

We will prove the existence of periodic orbits and speak of caustics, that are curves that sometimes appear if your ball has an infinite trajectory...

Prerequisites: norm, scalar product, angle, bisector, geometry of the triangle, area (for example area of a parallelogram), derivative, tangent and normal vector to a planar curve, linear momentum and kinetic energy.

TAs: *Richard Griffon, Marie Lhuissier, Coline Wiatrowski.*

Percolation

by *Christophe Garban*, Monday 27^{th}

The most well-known example of a phase transition is what occurs when water suddenly freezes when the temperature drops below 0 degree Celsius. Such phase transitions are omnipresent both in everyday life and in theoretical physics. A common feature shared by phase transitions is the fact that at equilibrium, when one varies the temperature gently, the structure of the system drastically changes at a precise critical temperature (and the two phases only coexist at that precise temperature).

The purpose of this talk will be to introduce a very simple, yet fascinating, mathematical model which will undergo such a phase transition. This model, called percolation, can be defined roughly as follows (more details will be given in the talk): consider the square grid in the plane, usually denoted by Z^2 (but you may also think of an infinite chessboard), and keep each edge of this grid independently with probability p (where p is some fixed parameter in the interval $[0,1]$). If $p = 1/2$, this means that for each edge, one tosses a fair coin to decide whether one keeps that edge or not. If $p < 1/2$, one would have to use a biased coin instead. Just to picture a little bit what this means: the higher p is, the denser the graph is (in fact the proportion of edges that are kept is given by the parameter p, usually called the "intensity"). The striking fact about this simple probabilistic model is that there exists a critical "temperature" $0 < p_c < 1$ such that when the intensity p is below p_c, then all the connected components of the random graph thus created are finite, while if $p > p_c$ there is a unique infinite connected component.

TAs: *Guillaume Aupy, Mikhail Hlushchanka, Simon Iosti.*

Quasicrystals in Nature and in Mathematics

by *Yves Meyer*, Monday 27^{th}

D. Shechtman was awarded the 2011 Nobel prize in chemistry for the discovery of quasicrystals in Nature. D. Shechtman's seminal paper was published in 1984. It soon became clear that quasicrystals had been studied previously by mathematicians (1970, 1974). Some Penrose tilings are spectacular examples of quasicrystals. Michel Duneau, Denis Gratias, and André Katz bridged the gap between mathematics and chemistry.

The aim of this lecture is to clarify the relation between quasicrystals and pavings. The Conway pinwheel paving is an exact pavings of the plane with isometric copies of one triangle. It is not a quasicrystal. We also study the role of number theory (Pisot and Salem numbers) in quasicrystals.

Quasicrystals were used as decorative patterns in medieval Islamic Art.

Art, mathematics and chemistry are reconciliated.

TAs: *Adriane Kaïchouh, Thomas Letendre, Christelle Vincent.*

The arctic circle
by *Vincent Beffara*, Tuesday 28^{th}

An other occurrence of the coexistence of two very different phases in a simple system is the following system, modeling the arrangement of molecules in a container. Consider a finite region formed of squares of the planar grid, and try to cover it by disjoint *dominos* (a domino is just a 2x1 rectangle). Sometimes it is impossible – think of a domain composed of an odd number of squares; sometimes there is a unique way to do it – think of a long and thin rectangle. But if the chosen domain is "nice", then typically there is a very large number of ways to do it.

What does a typical covering by dominos look like? Do the dominos tend to align, or are they completely disordered? As it turns out, for certain domains, the two behaviors occur at different locations, and the boundary between them, separating the ordered and disordered phases, is known as the "arctic circle" (because it separates a frozen region from a liquid one).

Understanding why there is such a brutal phase transition and where it occurs, although the model itself looks extremely simple, involves mathematics from very different fields, from probability and combinatorics to algebraic geometry; but quite a bit can be understood using only basic tools.
TAs: *Guillaume Aupy, Mikhail Hlushchanka, Simon Iosti.*

Shocks in fluids: formation, propagation and microscopic description
by *Laure Saint-Raymond*, Tuesday 28^{th} and Wednesday 29^{th}

The goal of this series of lectures is to show how to capture with mathematical models some physical phenomena exhibiting singularities: wave breaking, sound barrier...

The equation we will study, the so-called Hopf equation, is not – strictly speaking – an equation coming from physics, but it reproduces in a simple way the formation and propagation of singularities, and can be therefore considered as a prototype.

We will first describe its smooth solutions. To do that, we will introduce the method of characteristics, which reduces to solving ordinary differential equations. This explicit solution exhibits in general a singularity in finite time, time beyond which there is no more smooth solution. From the technical point of view, this session will aim at familiarizing with functions of several variables, and basics of differential calculus.

The second part of the course will be devoted to the dynamics in the presence of singularities. A natural question is to know how to define a weak notion of solution for differential equations, or in other words how to give sense to the derivative of a function which is not even continuous. In order to answer this question, we will give some elements about the theory of distributions. We will then discuss the uniqueness of weak solutions and physical admissibility criteria. The corresponding discussion session should consist in handling some classical distributions: Heaviside function, Dirac mass, principal value,...
TAs: *Selim Ghazouani, Richard Griffon, Michele Triestino.*

Translations surfaces and their geodesics
by *Jean-Christophe Yoccoz*, Tuesday 28^{th}

In a rectangular billiard with no friction, orbits are either periodic or equidistributed. The study of such billiards is very related to the study of rotations on a circle. In general, the study of the dynamics of a polygonal billiard table whose angles are commensurable to π leads to fascinating dynamical objects (interval exchanges) and geometrical objects (translation surfaces). We shall try to give an overview of this topic.
TAs: *Alessandro Carderi, Marielle Simon, Coline Wiatrowski.*

Kolmogorov complexity and algorithmic information theory
by *Alexander Shen*, Wednesday 29^{th}

It is usual to measure the amount of information in a message in bits. However, just the number of bits is not a good measure: message in 8-bit/char encoding and 16-bit/char have essentially the same information content even if the second one has twice more bits. More natural approach is to measure the "compressed size" of a message, but this depends on the compression technique; there are many compressor algorithms and none of them is "the right one". Andrei Kolmogorov and others (R. Solomonoff, and later G. Chaitin) found that one still have reasonably invariant definition of information content (= algorithmic complexity) and there is a rich theory around this notion. It also allows us to address the philosophical question: what is randomness? why we reject the fair coin hypothesis if we see 0101…0101 (1000 alternating bits) but some other sequence of 1000 bit may look plausible as the outcome of coin tossing? (Note that any two bit strings of length 1000 have the same probability if the coin is symmetric and coin tossings are independent).

We will try to discuss both mathematical properties of algorithmic complexity and its use in the foundation of probability theory. Some common sense as a prerequisite will be useful for the second part.

TAs: *Mikhail Hlushchanka, Simon Iosti, Marielle Simon.*

Teaching assistants

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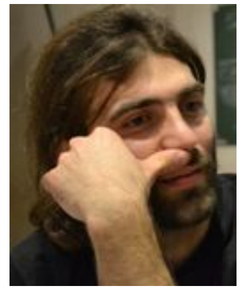

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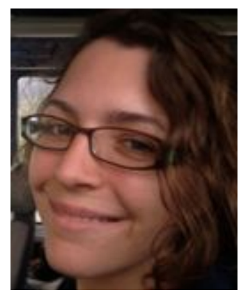

Christelle Vincent
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Coline Wiatrowski
ÉNS-Lyon (UMPA)

Greg Zitelli
University of Tennessee, Knoxville

	What	Tuesday 21st		Wednesday 22nd		Thursday 23rd		Friday 24th		Saturday 25th
8:00-9:00	**Beakfast**	breakfast		breakfast		breakfast		breakfast		breakfast
9:00-09:45	**Plenary lecture 1** (Descartes' Amphitheatre)	**Bob Connelly** Jammed packings in the plane		**Bob Connelly** Tensegrities : structures made with cables and struts - why do they hold up?		**John Conway** Topic to be decided democratically by participants		**Ken Ono** Combinatorics and number theory		Day trip
09:45-10:15	**Break**	break		break		break		break		
	Plenary lecture 2 (Descartes' Amphitheater)	**Matthias Kreck** Codes, arithmetic and manifolds		**Tadashi Tokieda** Invitation to simple modeling of complex phenomena		**Ken Ono** Combinatorics and number theory		**Gaiane Panina** Polytope algebra		
11:00-11:30	**Break**	break		break		break		break		
11:30-12:15	**Plenary lecture 3** (Descartes' Amphitheater)	**Tadashi Tokieda** Invitation to simple modeling of complex phenomena		**Shmuel Weinberger** Flows and walks on graphs		**Tadashi Tokieda** Invitation to simple modeling of complex phenomena		**Ken Stephenson** Circle packings		
12:15-13:15	**Lunch**	Lunch		Lunch		Lunch		Lunch		Pic-nic
13:15-14:30		Free time		Free time		Free time		Free time		Day trip
		What	**Where**	**What**	**Where**	**What**	**Where**	**What**	**Where**	
14:30-15:15	**3 parallel Lectures**	Bob Connelly	Roch	Bob Connelly	Roch	John Conway	Roch	Ken Ono	Roch	
		Matthias Kreck	Hizenbruch	Tadashi Tokieda	Hizenbruch	Ken Ono	Hizenbruch	Gaiane Panina	Hizenbruch	
		Tadashi Tokieda	Grothendieck	Weinberger	Grothendieck	Tadashi Tokieda	Grothendieck	Ken Stephenson	Grothendieck	
15:15-15:45	**Snack break**	snack break		snack break		snack break		snack break		
		What	**Where**	**What**	**Where**	**What**	**Where**	**What**	**Where**	
15:45-17:15	**9 discussion sessions**	Jammed packings in the plane	- Roch - Hizenbruch - Grothendieck	Flows and walks on graphs	- Roch - Hizenbruch - Grothendieck	Topic to be decided democratically by participants	- Roch - Hizenbruch - Grothendieck	Combinatorics and number theory	- Roch - Hizenbruch - Grothendieck	
		Codes, arithmetic and manifolds	- Moser - Kolmogorov - Arnol'd	Invitation to simple modeling of complex phenomena	- Moser - Kolmogorov - Arnol'd	Combinatorics and number theory	- Moser - Kolmogorov - Arnol'd	Polytope algebra	- Moser - Kolmogorov - Arnol'd	
		Invitation to simple modeling of complex phenomena	- Sinai - Ruelle - Bower	Flows and walks on graphs	- Sinai - Ruelle - Bowen	Invitation to simple modeling of complex phenomena	- Sinai - Ruelle - Bowen	Circle packings	- Sinai - Ruelle - Bowen	
17:30-17-45	**break**	break		break		break		break		
17:45-19:00		Free time		Free time		Free time		Free time		
19:30-20:00	**dinner**	dinner		Pic-nic		dinner		dinner		dinner
20:00-23:00	**20:30-23:00**	Game's night		Free time		Rally in Lyon Part 2		**Cinema preview : Chaos**		free time

	What	Sunday 26th		Monday 27th		Tuesday 28th		Wenesday 29th		Thursday 30th
8:00-9:00	**Beakfast**	breakfast		breakfast		breakfast		breakfast		breakfast
9:00-09:45	**Plenary lecture 1** (Descartes' Amphitheatre)	**Valentin Ovsienko** From complex numbers to quaternions and beyond		**Marie-Claude Arnaud** Billiards		**Vincent Beffara** Percolation		**John Conway** Topic to be decided democratically by participants		
09:45-10:15	**Break**	break		break		break		break		
	Plenary lecture 2 (Descartes' Amphitheater)	**Gaiane Panina** Polytope algebra		**Christophe Garban** Percolation		**Laure Saint-Raymond** Shocks in fluids : formation, propagation and microscopic description		**Alexander Shen** Kolmogorov complexity		Departure
11:00-11:30	**Break**	break		break		break		break		
11:30-12:15	**Plenary lecture 3** (Descartes' Amphitheater)	**Don Zagier**		**Yves Meyer** Quasicrystals		**Jean-Christophe Yoccoz** Translations surfaces and their geodesics		**Laure Saint-Raymond** Shocks in fluids : formation, propagation and microscopic description		
12:15-13:15	**Lunch**	Lunch		Lunch		Lunch		Lunch		
13:15-14:30		Free time		Free time		Free time		Free time		
		What	**Where**	**What**	**Where**	**What**	**Where**	**What**	**Where**	
14:30-15:15	**3 parallel Lectures**	Valentin Ovsienko	Roch	Marie-Claude Arnaud	Roch	Vincent Beffara	Roch	John Conway	Roch	
		Gaiane Panina	Hizenbruch	Christophe Garban	Hizenbruch	Laure Saint-Raymond	Hizenbruch	Alexandre Shen	Hizenbruch	
		Don zagier	Grothendieck	Yves Meyer	Grothendieck	Jean-Christophe Yoccoz	Grothendieck	Laure Saint-Raymond	Grothendieck	
15:15-15:45	**Snack break**	snack break		snack break		snack break		snack break		
		What	**Where**	**What**	**Where**	**What**	**Where**	**What**	**Where**	
15:45-17:15	**9 discussion sessions**	From complex numbers to quaternions and beyond	- Roch - Hizenbruch - Grothendieck	Billiards	- Roch - Hizenbruch - Grothendieck	Percolation	- Roch - Hizenbruch - Grothendieck	Topic to be decided democratically by participants	- Roch - Hizenbruch - Grothendieck	Departure
		Polytope algebra	- Moser - Kolmogorov - Arnol'd	Percolation	- Moser - Kolmogorov - Arnol'd	Shocks in fluids : formation, propagation and microscopic description	- Moser - Kolmogorov - Arnol'd	Kolmogorov complexity	- Moser - Kolmogorov - Arnol'd	
			- Sinai - Ruelle - Bowen	Quasicrystals	- Sinai - Ruelle - Bowen	Translations surfaces and their geodesics	- Sinai - Ruelle - Bowen	Shocks in fluids : formation, propagation and microscopic description	- Sinai - Ruelle - Bowen	
17:30-17-45	**break**	break		break		break		break		
17:45-19:00		Free time		Free time		Free time		Closing		
19:30-20:00	**dinner**	French typical food		dinner		dinner		dinner		
20:00-23:00	**20:30-23:00**			free time		free time		Dancing night		

4 Useful Information

4.1 Access to the residence and ÉNS de Lyon

Badges are essential for you to enter the ÉNS of Lyon, the residence and to attend the academic sessions and social events. Therefore we would like you to wear your badge at all times. You will receive two badges : one only for the entrance in the residence and the one you should wear at all time.
Entrance in the ENS of Lyon is free during these hours:

- from 7:45 am to 8:45 am
- from 2:15 pm to 2:30 pm
- from 7:15 pm to 7:45 pm

Outside these hours, you can ring and a person from the security will open the door for you, but it is better if you come during the opening hours. For security reasons, we will request that you sign at your arrival at the ÉNS on the morning, and at your definitive return to the residence on the evenings.

4.2 Meals

Meals are served in the restaurant (see the map for the location) and you have to give a ticket for each meal. Please contact a member of the local organization committee (Laura) if you haven't received these tickets with the welcome briefcase. Vegetarian and pork-free meals are available for people with a special diet. For lunch and dinner, you have to choose: 2 side dishes (like an appetizer and a dessert or two desserts), one main course and a piece of bread.

- Breakfast: from 7:45 am to 8:45 am
- Lunch: from 12:15 pm to 1:15 pm
- Dinner: from 7:00 pm to 8:00 pm

4.3 Coffee breaks

Drinks are served between the conferences in the Coffee Room (see the map for its location, near the restaurant). Coffee, tea, soft drinks and juices are proposed, together with snacks. **This Coffee Room is self-managed by the students**, so you have to be careful and maintain it clean. If drinks or food are missing, you can ask a member of the local organization committee. Also, each participant will receive a cup and will have to put his name on it, and use only this cup for drinks during the breaks, and please, leave cups there. **It is not allowed to bring any kind of drinks in the lecture halls**. Finally, try to be careful during these breaks and not miss the beginning of the following lecture!

4.4 Smoking

There are two restricted areas for smokers (see the map for more info).

4.5 Internet access

If you want to have an Internet access, you can either go the the Turing Room (where computers are available) or use your own computer. In latter case, connect to the "invites" wireless network, then launch an Internet browser, and use the following login and password:

Login: z400784 **Password: gqSrKECR**.

4.6 Emergency Numbers

Organization emergency numbers (you these numbers especially if you're trouble takes place inside the ÉNS or the residence):
Nicolas: +33630357198
Damien: +33760973151
ENS Security number : A AJOUTER
French emergency numbers (you cannot be sure to have an English speaker on the phone) :
Medical assistance: 15
Police: 17
Fire Brigade and Ambulance: 18

4.7 Library

Books are available in the (material room) and a loan scheme is set up. If you want a book which is not available in the (material room), we can loan it for you from the ENS library (you can check the catalog on http://primo.bibliotheque-diderot.org/primo_library/libweb/action/search.do?vid=BDD). For that, you have to fill a form, and we will get the book for the next day. The referent for the library is Michele (+336 99 07 69 27).

4.8 Free times

We advise you to attend all lectures. However, during the free times several possibilities are available for you.

The free times (note that you have to eat during those free times, see the meal section for the schedule of lunch and dinner) are:

- 12:15 am to 2:30 pm
- 5:30 pm to 8:30 pm

Work rooms

If you want to work by yourself or by groups, 6 rooms are available for you from 8:00 am to 11:00 pm, except during workshops. (LISTER LES SALLES)

Common room

This room is available during free times. There, you can read, play games, discuss with each other...

Sports

Several sports facilities are available during free times, such as a tennis court, a gym and a very big lawn. You can ask to borrow some equipment such as racquets, balls... The gymnasium is open during free times.

Outings

Participants have to be inside on the campus of the ÉNS from 9:00 to 5:30 pm. However, you can go back to the residence during the day, if you follow the procedure detailed below :

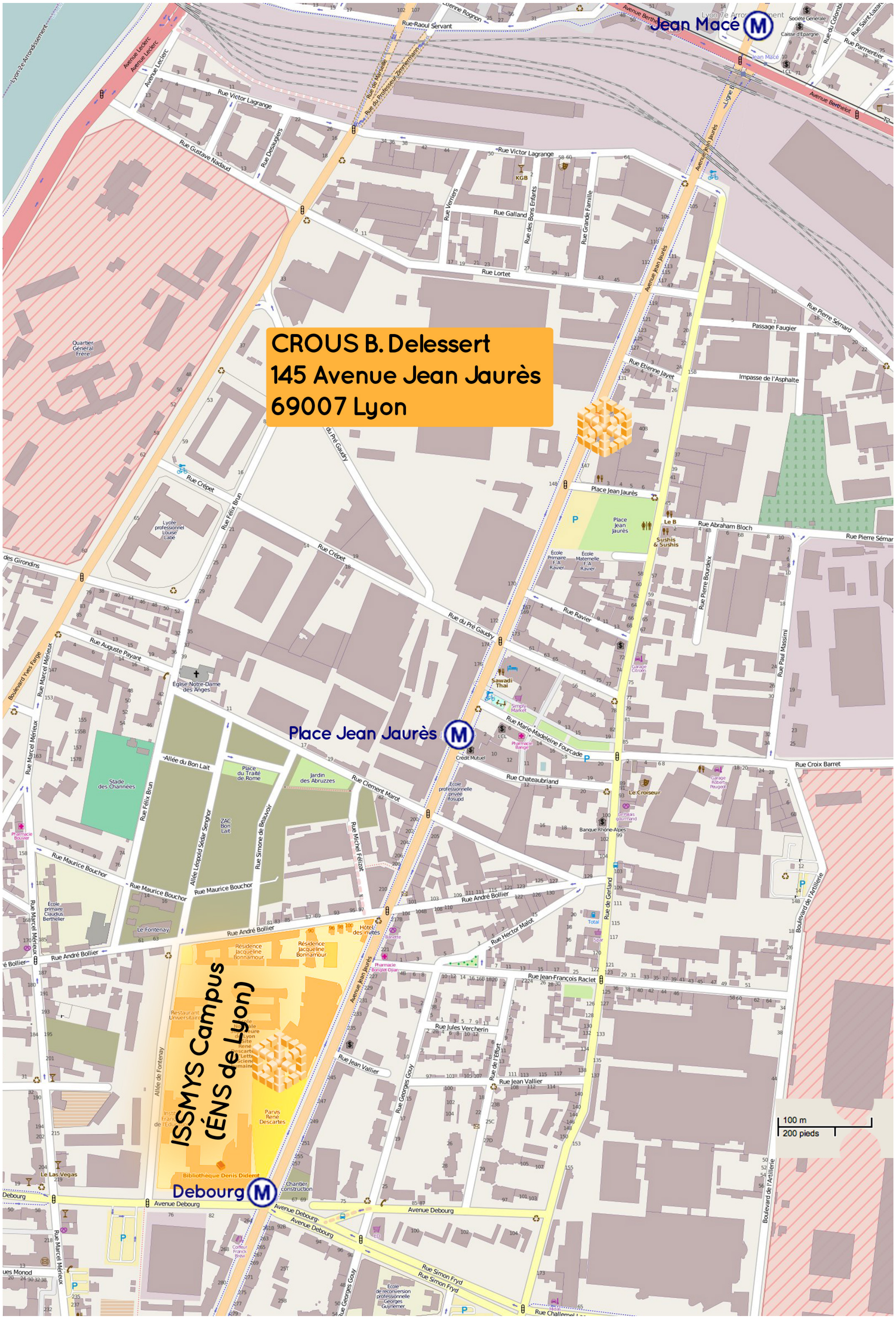
Going to the residence during the day
It is possible to go to the residence during the day and we will set up a notebook for you to note when you go out and when you come back. You can be alone when you go to the residence, but **you have to be noted**.

Evening outing in town
Outing in town is possible from 5:30 pm to 11:30 pm. When not accompanied by a supervisor, participants must move in groups of three minimum (for security reasons, if a student is hurt, one student stay with him, the other warn the rescue). For these outings, a notebook will also be set up, for you to report your departure and come back. This notebook will be available in the ENS of Lyon till 9:30 pm and in the Delessert Residence from 9:30 pm to 11:00. As for the residence outings, you **have to be noted** when you want to go in town. Finally, **you have to be inside the residence before 11:30 pm** when you come back.

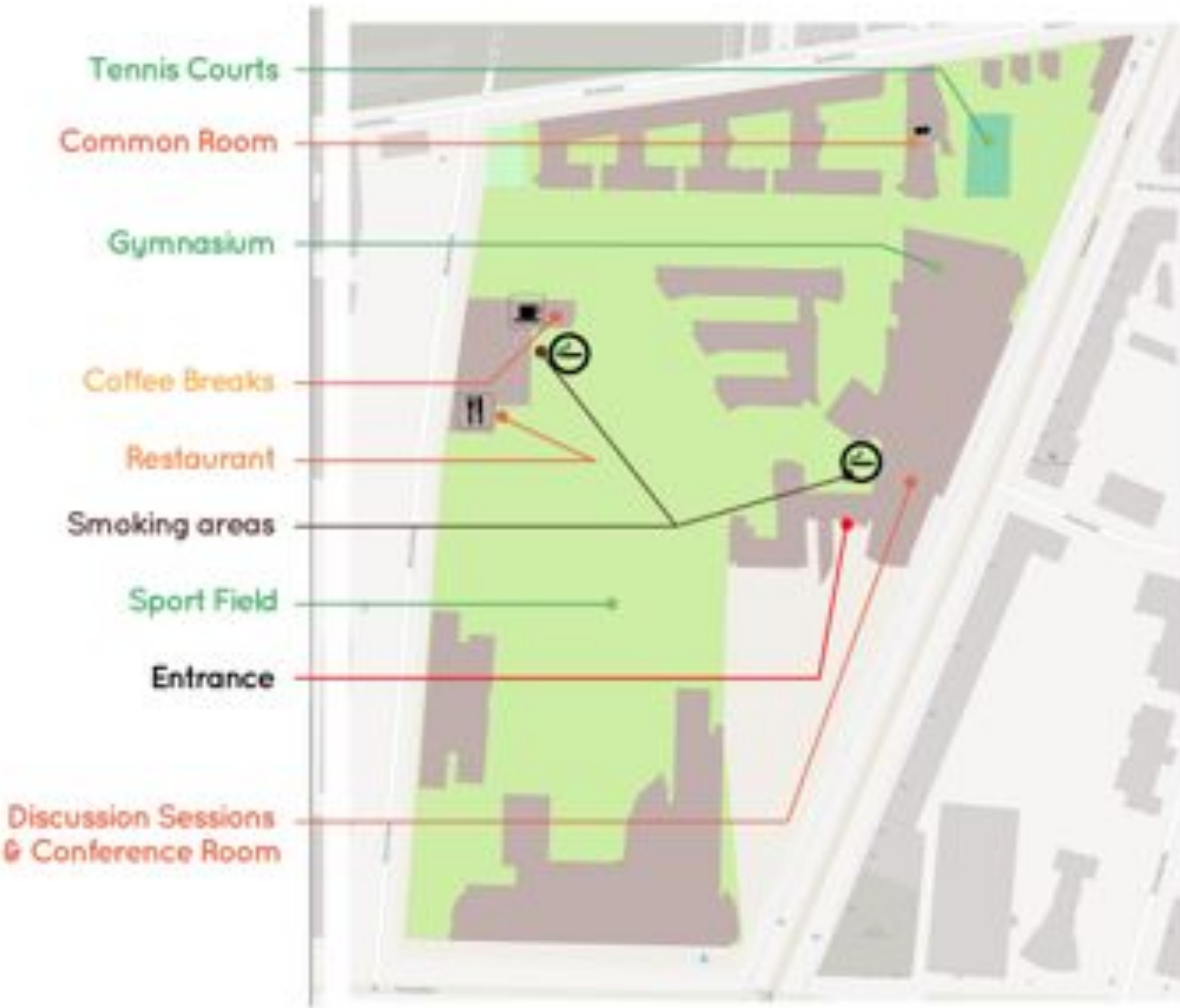
Public transportation

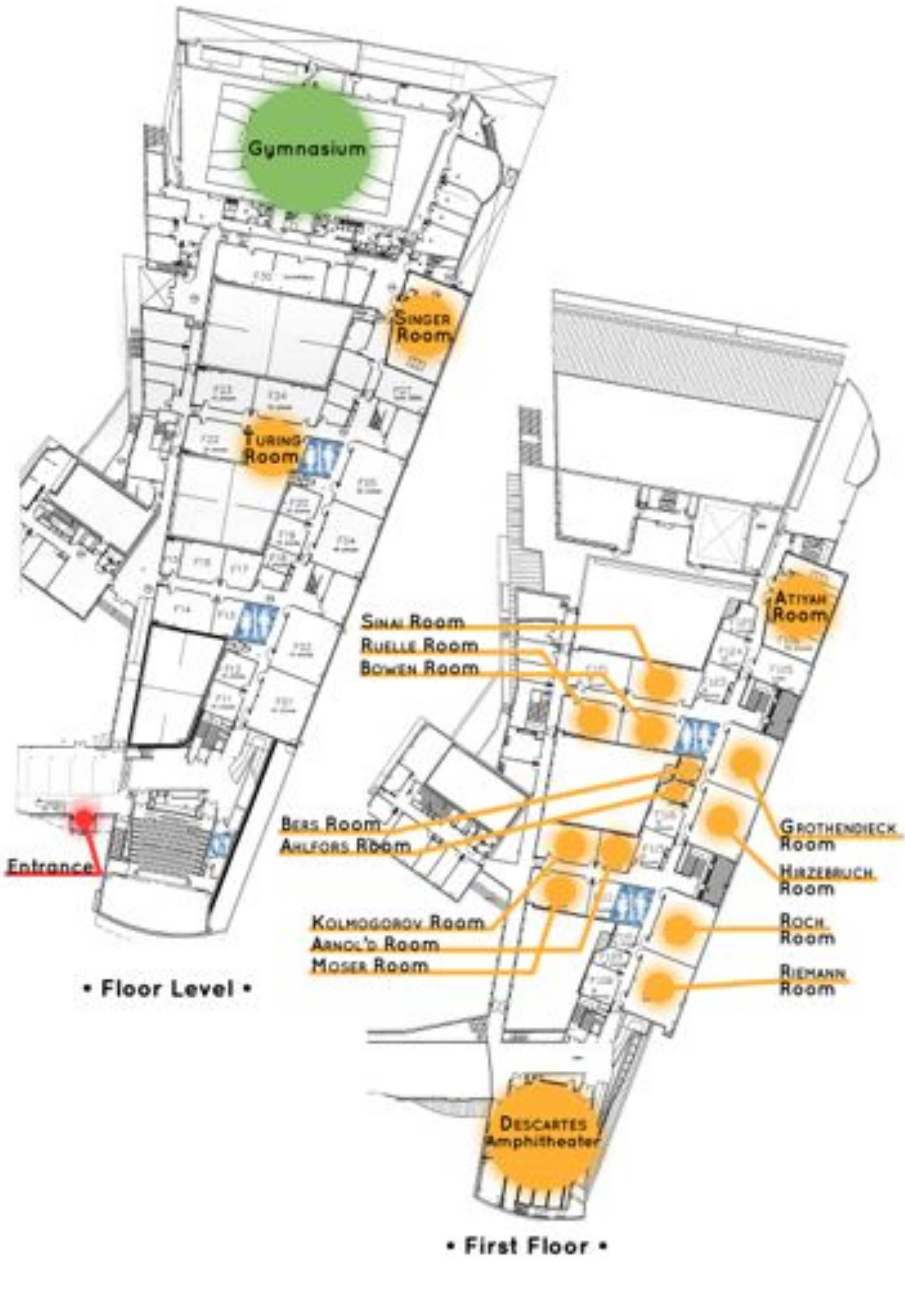
You can find in the bag 4 tickets for public transportations. These tickets are valid one hour after you obliterate them. There is also a map of Lyon and a map of public transportations.

4.9 Maps of the ENS



• Map of the ENS de Lyon •




Gymnasium
Singer Room
Turing Room
Entrance
• Floor Level •
Atiyah Room
Sinai Room
Ruelle Room
Bowen Room
Bers Room
Ahlfors Room
Grothendieck Room
Hirzebruch Room
Kolmogorov Room
Arnol'd Room
Moser Room
Roch Room
Riemann Room
Descartes Amphitheater
• First Floor •

5 Social Program

During your stay, you will have a choice between three day trips, which you've normally already chosen.

5.1 Opening Ceremony

5.2 Rally

On Thursday, the 23rd, we organize a rally in Lyon City. You will be parted in several teams, and you will have to visit different key locations in the city and answer a few questions about these to ensure you've really got there. If you encounter other teams during your game, you will have to challenge them or lose points... More details will be given about the rally on Wednesday!

5.3 Day trip

Lac des Sapins

Definitely the best way to exit the city and enjoy the outdoors doing sports! Literally translated into English as "the fir-trees' Lake", the Lac des Sapins is an artificial lake located in the region of Rhône-Alpes, 65 km northwest of the city of Lyon. This place will delight sportsmen/sportswomen or those who want to enjoy the relaxation. Indeed, many sports are proposed such as mountain biking, wind-surfing, volley ball, tree climbing, petanque, mini-stadium, fitness trail, pedal boat, swimming..., and of course sunbathing. And for nature lovers, it is possible to tour the lake on foot or by bike, and take advantage of the shade of trees.

Les grottes de la Balme (La Balme caves)

Definitely the best way to enjoy a walk in the middle of nature. Here we are in the north of Isere, 60 kilometres east of Lyons. With their monumental porch sculpted out of the limestone cliffs of the Isle Crémieu plateau, the La Balme caves are astonishing for the wealth and diversity of their undergrounds galleries. Used originally by prehistoric man as a shelter from the cold, the caves have been used for many different purposes over the centuries: a hiding-place for the smuggler, a place of pilgrimage for King François I... and a dance hall for the local village! Since 1807 they have been open to the public. The tour of the caves starts in the surprisingly-vast dome room whose ceiling is an impressive forty meters high! Numerous galleries lead away from the dome room and they all have intriguing names, such as Mandrin Labyrinth, Lake Gallery, Desert Gallery... Admire the slow and meticulous work of running water! Less than 100 meters from the entrance of the Caves, you will find a hiking trail starting. The trail, which extends over 8.5 kilometers, is traveled at a leisurely pace in three hours. It takes you on the board of Isle Crémieu, where you will discover the village and its hamlets, Parmilieu, and in good weather, the view of the Bugey and snow-capped Alps.

Lyon city and museum

Definitely the best way to discover the rich history of Lyon and stroll the streets.
The Basilica of Fourvière. You will start your day at the basilica, which was built on the Fourvière hilltop and is overlooking the city of Lyon and its surroundings. Indeed, on a clear day, you can see the Mont Blanc, the highest mountain in Europe.
Gallo-Romain museum of Lyon Fourvière. Lyon, former "Lugdunum" Gaul capital and the heir to a wealth of Gallo-Roman heritage, created the Fourvière site which is an exceptional place of remembrance, enriched with an exceptional history and character. Made unique by the richness of its collections, environment, and elaborate architecture, the museum offers a real journey through time.
A walk through the old Lyon and its "Traboules". This Renaissance district, listed by Unesco, is the largest area of this kind in France... This unique area of Gothic and Renaissance architecture has been chosen by UNESCO as World Heritage. It covers 24 hectares along the banks of the river Saone. Old Lyon's urban development mainly took place in the 15th and 16th centuries. After visiting the Gothic cathedral, wander through the narrow cobbled streets and "traboules" these famous covered passageways going from one street to the next via corridors through houses hide superbly renovated architectural treasures: inner courtyards, galleries "à l'italienne", spiral staircases etc.
Fine Arts Museum. Set in the heart of the city, the 1998 fully renovated Lyon Fine Arts Gallery houses one of France's richest collection of art masterpieces. Its 70 rooms are divided into 5 main departments, exhibiting works from the greatest periods of art: from ancient Greek, ancient Egyptian, sculptures, paintings, decorative, the Middle Ages right up to the present day. The department dedicated to antiques and archaeological piece presents artefacts ageing 3000 years, illustrating the world former civilizations- Egypt, Middle-East, Oriental, Italian, Greek etc.

5.4 Dancing night

Wednesday, the 29th, will be the last day of ISSMYS. Therefore, we organize a party to celebrate those last few days with you!

6 Sponsors

We would like to thank the following institutions for sponsoring ISSMYS 2012 with human, financial and technical resources:

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