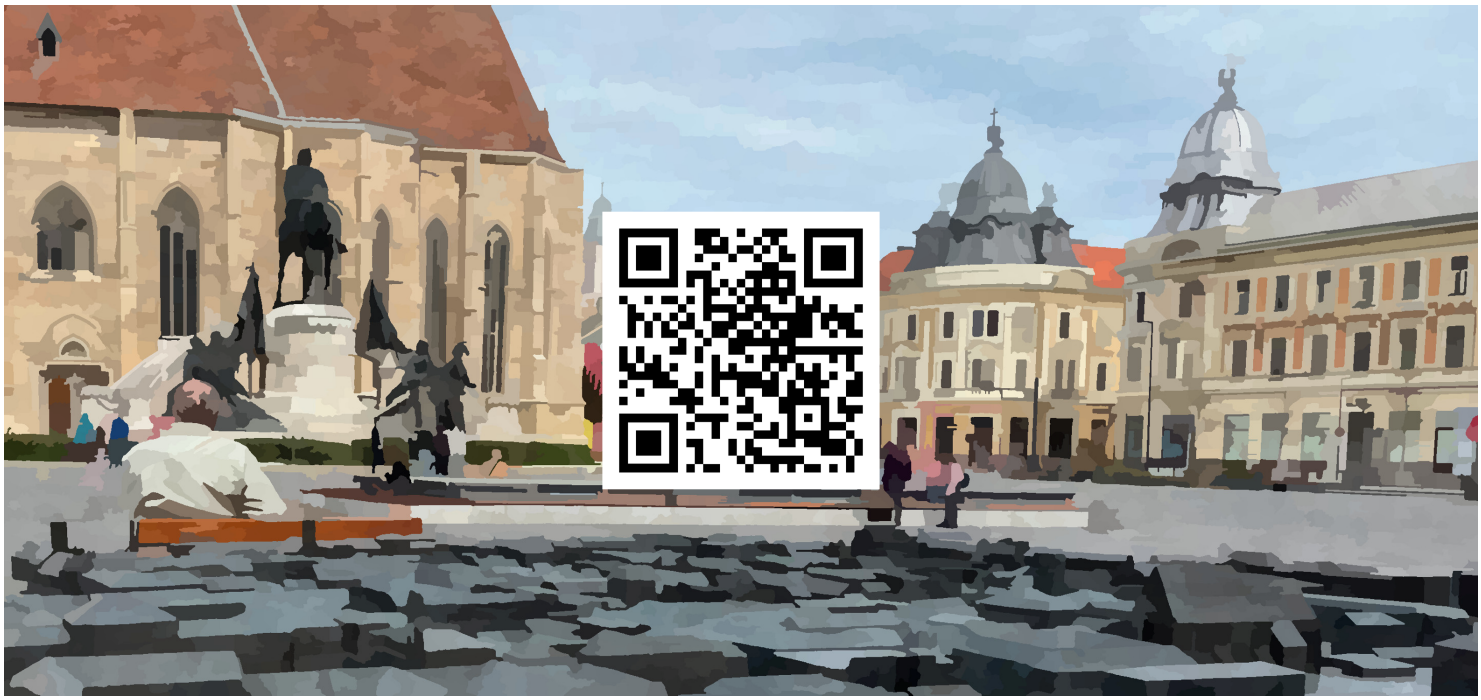
Comunicări Științifice ale Studenților
Matematică, UBB

Secțiunea: Licență-Masterat

Sala de Lectură

Clădirea Mathematica, str. Ploiești 23-25, Cluj-Napoca

Universitatea Babeș-Bolyai
Facultatea de Matematică și Informatică
Departamentul de Matematică



PROGRAM

10:45-11:00 Deschidere		
11:00	Alin-Florin Badea	Evaluarea Probabilistică a Riscului Seismic în Municipiul București utilizând Simulări Monte Carlo
11:15	Codrin-Gabriel Lateș	A Lean 4 Formalization of Thales' Intercept Theorem
11:30	Miruna Periețeanu	Bassian Objects in Abelian Categories
11:45	Tudor-Marian Buta	Structuri Algebrice în Simetria Moleculară
12:00	Luiza Chenți	Modelul SIR: Tratament Teoretic și Simulare Numerică a Dinamicii Epidemiologice
12:15	Emanuel Corlat	Minimizarea consumului de combustibil în conducerea automobilelor
12:30-12:45 Pauză		
12:45	Oana-Maria-Cătălina Crișan	A Stochastic Optimal Control Approach on Modeling Methylphenidate Pharmacodynamics in ADHD via Hybrid Neural Networks
13:00	Iris-Ana Füredi	O Abordare prin Algebră Liniară a Teoriei lui Galois
13:15	Adina Nicoleta Gui	Modelarea matematică a dinamicii celulelor tumorale și a răspunsului la tratament
13:30	Rareș Răhăian	The Elliptic Cauchy Problem with Applications in Electrocardiographic Imaging
13:45	Andreea Ioana Mărginean	Mathematical Models of Population Growth
14:00	Elena-Tamara Ivanof	Monte Carlo Methods and Applications
14:15-14:30 Pauză		
14:30	Andrei Nicoară	Reprezentări de Categorii
14:45	Maria Kaproș	Complexity Analysis in Neuroscience. An Overview
15:00	Alesia-Dalia Stan	Aplicabilitatea Teoremei de Colaj în Modelarea Geometrică a Naturii
15:15	Ákos Tordai	On the Flow Lattice of Planar Graphs and Their Duals
15:30	Alexandru-Andrei Popescu	Împărțirea cu Rest în $\mathbb{Z}[\sqrt{14}]$
15:45	Zsuzsa Nagy	The Geometry of Systems of Proportionally Modular Numerical Semigroups
16:00	Alexia-Dana Hudea	Control Problems in Chemostat
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ABSTRACTE

10:45-11:00 Deschidere

11:00 **Alin-Florin Badea** (UBB, FMI, Matematică-Informatică, an 3)

Titlu: **Evaluarea Probabilistică a Riscului Seismic în Municipiul București utilizând Simulări Monte Carlo**

Îndrumător: Conf. Natalia Roșca

Abstract: This thesis proposes a computational model for seismic risk assessment in Bucharest, transitioning from deterministic models toward an advanced stochastic approach. The primary objective is to quantify the aleatory uncertainties of the Vrancea subcrustal source and structural degradation through a custom Monte Carlo simulation engine implemented in MATLAB.

At the core of the methodology is the iterative stochastic sampling of the focal parameter space, conducted over 5,000 simulation runs to ensure statistical convergence. For each iteration, magnitude, focal depth, and epicentral distance are extracted from continuous uniform distributions and propagated via Ground Motion Prediction Equations (GMPE). A key mathematical contribution is the analytical derivation of median capacity thresholds through a sequence of functional transformations. This process maps interstory drift ratios to spectral displacements and, subsequently, to Peak Ground Acceleration (PGA) limits, calibrated to the dynamic structural properties of the analyzed stock of 48,862 reinforced concrete buildings of Bucharest, categorized into four distinct design eras. Structural failure is modeled by evaluating these thresholds against simulated seismic demand through lognormal fragility functions, capturing the multiplicative nature of concrete collapse.

The macro-level results indicate a mean expectation of 1,202 collapsed units (2.46% of the stock). However, an analysis of the "heavy tail" of the resulting probability distribution reveals extreme scenarios exceeding 15,900 collapses, highlighting the necessity of accounting for statistical outliers in disaster mitigation. The computational innovation lies in the micro-level study of Magheru Boulevard. By modeling the debris fall radius as a geometric function of building height (H/2), the algorithm evaluates the intersection of debris fields across the roadway. By grouping buildings into dual spatial pairs, the simulation identifies a mean of 4.91 collapses along the segment and a 17.48% critical probability of simultaneous bilateral collapse. This scenario points to a systemic failure of the city's primary North-South emergency artery, demonstrating that stochastic simulations and computational geometry are indispensable tools for proactive civil protection and crisis management.

11:15 **Codrin-Gabriel Lateș** (UBB, FMI, Matematică-Informatică, an 2)

Titlu: **A Lean 4 Formalization of Thales' Intercept Theorem**

Îndrumător: Lect. Iulian-Ion Simion

Abstract: Formalizing classical geometry in a proof assistant requires making implicit assumptions explicit and resolving ambiguities that informal proofs leave open. This talk works through that process using Thales' Intercept Theorem in Lean 4.

We open with a brief introduction to Lean 4, what it is, how it expresses mathematical statements, and why formal verification is worth doing. We then present the formalization of the theorem: how it is stated precisely, which abstractions are used and why, and where geometric intuition requires the most care to translate into a formal proof.

The talk concludes by situating this work within recent formalization efforts in mathematics, and what they suggest about the role of proof assistants in current mathematical practice.

11:30 **Miruna Perieţeanu** (UBB, FMI, Matematică-Informatică, an 2)

Titlu: **Bassian Objects in Abelian Categories**

Îndrumător: Prof. Simion-Sorin Breaz

Abstract: An object X in an Abelian category is (generalized) Bassian if the existence of a monomorphism $j : X \to X/X'$ for a subobject X' of X implies that $X' = 0$ (X' is a direct summand of X). This presentation aims to express relationships between the Bassian condition and other finiteness conditions and to provide useful characterizations of the definitions of some of these conditions in categorical language. Our results generalize the connections discovered by Patrick Keef for Abelian groups and Soumitra Das, M. Tamer Koşan, Özgür Taşdemir and Jan Žemlička for modules.

11:45 **Tudor-Marian Buta** (UBB, FMI, Matematică-Informatică, an 3)

Titlu: **Structuri Algebrice în Simetria Moleculară**

Îndrumător: Asist. Virgilius-Aurelian Minuță

Abstract: În această prezentare studiem grupurile de simetrie ca instrument matematic pentru clasificarea și analiza moleculelor chimice. Construim grupurile diedrale D_n ca grupuri de simetrie ale poligoanelor regulate și identificăm structura lor algebrică - generatori, relații și izomorfisme. Trecem apoi la grupurile punctuale moleculare, prezentând operațiile de simetrie fundamentale: rotații C_n, reflexii σ și centrul de inversie i. Analizăm o selecție reprezentativă de grupuri punctuale - de la cele mai simple, fără nicio simetrie, până la cele cu simetrie maximă - ilustrate prin molecule concrete din chimia organică și anorganică, și evidențiem legătura dintre structura grupului și proprietățile fizice ale moleculei, în particular polaritatea și chiralitatea. Încheiem cu o privire asupra aplicațiilor teoriei grupurilor în spectroscopie moleculară.

12:00 **Luiza Chenți** (UBB, FMI, Matematică-Informatică, an 3)

Titlu: **Modelul SIR: Tratament Teoretic și Simulare Numerică a Dinamicii Epidemiologice**

Îndrumător: Prof. Adrian-Olimpiu Petrușel

Abstract: Această lucrare prezintă un studiu comprehensiv al modelului epidemiologic compartimental SIR (Susceptibil-Infectat-Recuperat), realizând o punte între analiza matematică riguroasă a sistemelor dinamice și simulările numerice aplicate. Obiectivul principal al cercetării este investigarea calitativă a sistemului de ecuații diferențiale ordinare neliniare care guvernează propagarea bolii. Din punct de vedere analitic, lucrarea detaliază deducerea numărului de reproducere bazal prin metoda matricii următoarei generații (NGM), analizează invarianța domeniului și demonstrează stabilitatea globală a echilibrului endemic utilizând Metoda Directă a lui Lyapunov.

În plan computațional, studiul justifică limitările analitice (precum ecuația transcendentală a dimensiunii finale) și fundamentează necesitatea metodelor de aproximare cu regiuni extinse de stabilitate absolută. Prin studiul ecuației Dahlquist, se demonstrează superioritatea algoritmului Runge-Kutta de ordinul 4 (RK4) în rezolvarea sistemelor biologice rigide. Partea aplicativă a lucrării constă în dezvoltarea de la zero a unui mediu de simulare în limbajul Python. Programul permite integrarea numerică și analiza de sensibilitate a diverșilor parametri, facilitând modelarea vizuală a unor scenarii critice de sănătate publică, precum evoluția naturală a epidemiei, impactul distanțării sociale (carantinei) și efectul imunizării de turmă prin campanii de vaccinare.

12:15 **Emanuel Corlat** (UBB, FMI, Matematică-Informatică, an 3)

Titlu: **Minimizarea consumului de combustibil în conducerea automobilelor**

Îndrumător: Asist. Virgilius-Aurelian Minuță

Abstract: Odată cu trecerea timpului și creșterea nivelului de experiență, șoferii auto adoptă diverse stiluri și manierisme de condus, ce afectează drept urmare eficiența exploatării motorului termic. Prin intermediul sistemelor dinamice, studiul analizează diferența consumului mediu final de combustibil între diverse metode de a menține viteza și accelerația dorite ale vehiculului pe diverse sectoare de drum, căutând apropierea de eficiența maximă.

12:30-12:45 Pauză

12:45 **Oana-Maria-Cătălina Crișan** (UBB, FMI, Matematică, an 3)

Titlu: **A Stochastic Optimal Control Approach on Modeling Methylphenidate Pharmacodynamics in ADHD via Hybrid Neural Networks**

Îndrumători: Lect. Oana-Andrea Lang, Prof. Adrian-Olimpiu Petrușel

Abstract: This work presents a mathematical framework for modelling the effectiveness of Methylphenidate (MPH) as an optimal control policy acting on the nonlinear dynamics of neurodivergent brain activity in attention-deficit hyperactivity disorder (ADHD). Neural processes in ADHD can be conceptualized using stochastic processes with trajectories that converge towards stable, yet maladaptive patterns associated with clinical symptoms. The action of MPH is modeled as an external control that reassesses the system's drift and redirects the trajectories towards neurotypical (stable) regimes. From a probabilistic perspective, this can be interpreted as a change of measure in the sense of Girsanov's theorem. Optimality is defined using the minimal Kullback-Leibler divergence from target dynamics. Latent representations are inferred using a hybrid deep learning architecture that combines a one-dimensional Convolutional Neural Network and a Vision Transformer, trained on preprocessed fMRI data. The model achieves an overall accuracy of 75.67% ± 3.62% and enables the simulation of optimized controlled trajectories. Overall, this research provides a comprehensive mathematical and computational representation on the stabilization of brain dynamics under pharmacological intervention.

13:00 **Iris-Ana Füredi** (UBB, FMI, Matematică-Informatică, an 3)

Titlu: **O Abordare prin Algebră Liniară a Teoriei lui Galois**

Îndrumător: Asist. Virgilius-Aurelian Minuță

Abstract: În cadrul acestei prezentări vom aborda o expunere alternativă a Teoremei fundamentale a teoriei lui Galois, bazată în mod esențial pe instrumente de algebră liniară.

Vom introduce o definiție liniar-algebrică a extinderilor Galois bazată pe o condiție de diagonalizare și vom discuta demonstrația teoremei fundamentale folosind extinderea scalarilor și independența liniară a automorfismelor de corp. Scopul principal al prezentării este de a oferi o nouă intuiție matematică, demonstrând cum un fundament de algebră liniară poate clarifica și simplifica asimilarea unor concepte profunde din teoria corpurilor, evitând astfel dificultățile tehnice asociate studiului clasic al grupurilor rezolubile.

13:15 **Adina Nicoleta Gui** (UBB, FMI, Matematică, an 3)

Titlu: **Modelarea matematică a dinamicii celulelor tumorale și a răspunsului la tratament**

Îndrumător: Lect. Lorand Parajdi

Abstract: Mathematical modeling plays a fundamental role in understanding complex processes in cancer biology, providing insights that complement experimental and clinical studies. In particular, the analysis of tumor cell dynamics is essential for estimating tumor growth and evaluating treatment strategies. In this work, we analyze a mathematical model described by the system:

$$\begin{cases} N' = \frac{aN}{1+bN} - cN - \mu AN \\ A' = \alpha(t) - \lambda A - \gamma AN \end{cases}.$$

Here, $N(t)$ represents the number of tumor cells, while $A(t)$ denotes the drug concentration. The model parameters include the tumor growth rate a, the natural death rate c, and a saturation (crowding) effect represented by $\frac{1}{1+bN}$. The parameter μ describes the drug-induced cell mortality rate, λ is the drug decay rate, γ accounts for drug consumption during tumor cell elimination, and $\alpha(t)$ represents the drug administration rate. This system describes the evolution of a solid tumor under treatment, allowing us to examine the impact of therapy on tumor growth dynamics and to reveal key qualitative properties of the system.

13:30 **Rareș Răhăian** (UBB, FMI, Informatică, ger, an 3)

Titlu: **The Elliptic Cauchy Problem with Applications in Electrocardiographic Imaging**

Îndrumător: Lect. Mihai Nechita

Abstract: The elliptic Cauchy problem is a classical example of a severely ill-posed inverse problem, in which the solution of an elliptic PDE must be reconstructed from incomplete and noisy boundary data. We focus on the setting in which the unknown boundary trace is assumed to belong to a finite-dimensional space, as arises naturally in some applications. We analyze how this assumption tightens stability bounds from logarithmic to Lipschitz. We also explore the proposed methods in the context of electrocardiographic imaging (ECGi), which is a direct application of the elliptic Cauchy problem in the field of biomedical imaging, where we explore data-enhanced regularisation methods. Numerical experiments are presented to illustrate the approaches.

13:45 **Andreea Ioana Mărginean** (UBB, FMI, Matematică-Informatică, en, an 3)

Titlu: **Mathematical Models of Population Growth**

Îndrumător: Lect. Veronica-Ana Ilea

Abstract: The study of natural phenomena has led to the development of mathematical models capable of describing, in an abstract form, their characteristics. In the case of population dynamics, one of the most suitable approach is given by differential equations, or systems of differential equations. This paper focuses on mathematical models of population growth, with emphasis on the exponential and logistic models. The study also extends to interacting population models through the Lotka-Volterra system, describing the dynamic between predator and prey species.

14:00 **Elena-Tamara Ivanof** (UBB, FMI, Inteligență Artificială, an 3)

Titlu: **Monte Carlo Methods and Applications**

Îndrumător: Prof. Sanda Micula

Abstract: Monte Carlo methods are numerical algorithms which use repeated random sampling to approximate quantities such as probabilities, means, standard deviations, areas and volumes in problem settings where an analytic solution is not always feasible. This report presents the theoretical concepts and the main algorithms related to sampling and conducting a Monte Carlo study. Additionally, it showcases some interesting applications of Monte Carlo methods in the field of computational mathematics, with a special focus on Monte Carlo Integration, a probabilistic alternative to classical quadrature algorithms.

14:15-14:30 Pauză

14:30 **Andrei Nicoară** (UBB, FMI, Matematică-Informatică, an 3)

Titlu: **Reprezentări de Categorii**

Îndrumător: Prof. Andrei-Dorin Mărcuș

Abstract: În lucrare prezentăm trei rezultate principale. Primul stabilește că *categoria k-algebrelor asociative cu unitate este izomorfă cu categoria categoriilor k-liniare cu un singur obiect*, oferind o traducere precisă a obiectelor algebrice în obiecte categoriale. Al doilea rezultat extinde această corespondență la cazul echivariant: pentru un grup G și un inel comutativ k fixate, *categoria G-algebrelor peste k este izomorfă cu categoria functorilor* $\mathrm{Funct}(\mathcal{G}, \mathbf{Alg}_k)$, unde $\mathcal{G}$ este categoria cu un singur obiect asociată grupului G. În al treilea rând, combinând cele două perspective, demonstrăm un izomorfism între *categoria G-k-algebrelor și categoria* G-$\mathbf{Cat}_k^1$, care unifică acțiunile de grup și descrierea categorială într-un singur cadru.

14:45 **Maria Kaproș** (UBB, FMI, Matematici Avansate, an 1)

Titlu: **Complexity Analysis in Neuroscience. An Overview**

Îndrumător: Lect. Oana-Andrea Lang

Abstract: I will present a synthesis of the background and related work relevant for my dissertation focused on using complexity analysis to improve our understanding of neuronal processes and potentially provide biomarkers for psychopathology such as mood and anxiety disorders. Due to the complex dynamics of the brain, traditional statistical methods cannot find the relationships between neural signals (from multi-channel recordings such as EEG) or detect changes in neural activity. Hence, researchers rely on measures derived from non-linear dynamics (fractal dimension, entropy) to characterize the "complexity" of neural states. In this talk, I will provide an overview and theoretical explanation of existing EEG complexity measures and synthesize complexity findings across different areas of psychological science.

15:00 **Alesia-Dalia Stan** (UBB, FMI, Matematici Avansate, an 1)

Titlu: **Aplicabilitatea Teoremei de Colaj în Modelarea Geometrică a Naturii**

Îndrumător: Conf. Brigitte Erika Breckner

Abstract: Geometria euclidiană se bazează pe forme ideale care nu reușesc să surprindă cu acuratețe complexitatea lumii reale. Această prezentare explorează geometria fractală ca punte între matematica abstractă și formele organice, utilizând Teorema Colajului. Analiza pornește de la modele clasice (triunghiul Sierpinski, fulgul de zăpadă Koch) și evoluează spre exemple din natură, precum conopida Romanesco. Obiectivul este de a demonstra modul în care Sistemele de Funcții Iterative (IFS) pot recrea obiecte cotidiene prin funcții matematice precise.

15:15 **Ákos Tordai** (UBB, FMI, Matematică, an 3)

Titlu: **On the Flow Lattice of Planar Graphs and Their Duals**

Îndrumător: Conf. Tamás László

Abstract: Among the structures assignable to planar graphs, the flow lattice provides an algebraic characterization of the cycles existing on the graph. By treating this in the context of singularity theory, we can arrive at new connections.

The flow lattice assigned to a directed graph possesses a positive definite, symmetric intersection form; however, its construction can yield different bases. We have proved that there always exists an orientation and a choice of basis such that the generators are the primitive cycles, their self-intersection equals the size of the cycle they represent, and their mutual intersection encodes the common edges of the cycles. Through this, the flow lattice encodes the adjacency of the original graph with respect to its primitive cycles, and can be represented by a so-called dual graph. This latter representation corresponds to the resolution graph of a surface singularity. This graph encodes the topology of the surface in a neighborhood of the singular point.

The paper, highlighting this new connection, proves that the dual graph assigned to every graph corresponds to the resolution graphs of minimal rational singularities. Furthermore, we found a correspondence between the fundamental cycle of the associated singularity and closed walks on the boundary of the original graph. On the vertices of graphs one can define the so-called "chip-firing" game, in which one vertex is designated as the sink (which cannot be fired) and every other vertex receives a given number of chips. "Firing" a vertex means sending as many chips to each neighboring vertex as there are edges between them, while the sink absorbs all chips fired into it. A chip configuration on the vertices is stable if no vertex can be fired, and superstable if after any simultaneous firing there is guaranteed to be a negative chip count at some vertex. The algebraic model of this game is called the sandpile model, and it encodes a great deal of information about the original graph. Using the sandpile model defined on the associated singularity, we also made a superstability criterion more efficient. Finally, we investigated the singularity-theoretic construction of the Tutte polynomial of the original graph, along with the associated coloring and flow problems.

All of this constitutes the study of graph-theoretic and graph-algebraic problems using topological and combinatorial methods, representing a new approach to the given topic and facilitating the answering of several questions.

15:30 **Alexandru-Andrei Popescu** (UBB, FMI, Metode Moderne în Predarea Matematicii, an 2)

Titlu: **Împărțirea cu Rest în $\mathbb{Z}[\sqrt{14}]$**

Îndrumător: Prof. Simion-Sorin Breaz

Abstract: Studiem împărțirea cu rest în $\mathbb{Z}[\sqrt{14}]$, un inel care este euclidian, dar nu prin norma sa uzuală. Folosind construcția lui Motzkin și rezultatul lui Harper [$\mathbb{Z}[\sqrt{14}]$ is Euclidean, Canadian Journal of Mathematics, 56(1):55-70, 2004], obținem existența unei funcții euclidiene minimale, care garantează împărțirea, dar fără a oferi un algoritm explicit. Vom discuta câteva exemple care arată cum am putea, în practică, să realizăm împărțirea.

15:45 **Zsuzsa Nagy** (UBB, FMI, Matematică, an 3)

Titlu: **The Geometry of Systems of Proportionally Modular Numerical Semigroups**

Îndrumător: Conf. Tamás László

Abstract: The fundamental question of our research can be traced back to understanding the solutions of proportionally modular Diophantine inequalities. But what makes these solutions particularly interesting? First, they exhibit "well-behaved" algebraic properties; secondly, they encode important features in singularity theory. The solution set defined by a system of Diophantine inequalities turns out to be a numerical semigroup, more precisely, a system of proportionally modular numerical semigroups (abbreviated as SPM).

The notion of SPM was first introduced by J. C. Rosales, P. A. García-Sánchez, J. I. García-García, and J. M. Urbano-Blanco in their 2003 paper *Proportionally Modular Diophantine Inequalities*, where it appears as a natural extension and systematization of proportionally modular numerical semigroups. The study of these objects, as par of the theory of numerical semigroups, raises several important questions: how to interpret the invariants of numerical semigroups; how to characterize the largest gap (the Frobenius number); how to determine the number of gaps (the genus); how to represent the number of generators; and how these SPMs arise structurally from the numerical semigroups (proportionally modular numerical semigroups, PM) associated with the individual Diophantine inequalities in the system.

In our research, we investigate the geometry and topology of such systems of numerical semigroups. A specific property of complex normal surface singularities is that the topology of the surface around the singular point is encoded by a negative-definite weighted graph (the so-called resolution graph). In our particular setting, we consider a class of singularities, namely, weighted homogeneous surface singularities, whose resolution graphs are star-shaped trees. To such singularities, one can naturally associate a numerical semigroup, which admits a combinatorial interpretation in terms of the resolution graph.

Reversing this perspective, we say that a numerical semigroup is representable if it can be realized as the numerical semigroup of a star-shaped resolution graph.

The main result of our thesis establishes that SPM numerical semigroups are representable. Moreover, we show how to construct such a representation of an SPM semigroup based on a decomposition into PM semigroups. This approach provides a framework for studying the properties of SPMs not only from an algebraic viewpoint, but also via the topological and combinatorial tools of singularity theory.

16:00 **Alexia-Dana Hudea** (UBB, FMI, Matematici Avansate, an 2)

Titlu: **Control Problems in Chemostat**

Îndrumător: Conf. Marcel-Adrian Șerban

Abstract: The presentation follows to present a control problem in a chemostat which studies the necessary quantity of the nutrients that has to be introduced in a chemostat in order to obtain a certain volume of a bacteria population that consumes that type of nutrient.

16:15 Mini-Ceremonie de Închidere