Program	Type of studies (cycle)	Third cycle
	Name of the program	Doctoral Studies in Mathematical and Computer Science

Course

Course title	**Heat and wave kernels on manifolds and discrete structures: analytical and combinatorial aspects**

Course code	Semester	Course status	ECTS credits	Contact hours
PMAT 603	II	Elective	10	30

Aims and intended learning outcomes	The course provides a framework for understanding the existence, uniqueness, and applications of heat and wave kernels in continuous and discrete spaces and in continuous and discrete time. It connects analytical techniques from partial differential equations and operator theory with combinatorial applications, introducing contemporary problems in geometric analysis and network theory, with applications in physics, number theory, and combinatorics.

Course content/topics

- Solving the heat and wave equations on $\mathbb{R}^n$ and on manifolds
- Existence and uniqueness of solutions
- Asymptotic expansions
- The Laplace–Beltrami operator and geometric analysis
- Existence and uniqueness
- The parametrix approach to constructing solutions
- Graph Laplacians and the random walk interpretation of diffusion on graphs
- Existence and uniqueness of heat and wave kernels on graphs
- Applications in combinatorics
- Applications in mathematical physics (metric graphs)
- Trace formulas for heat and wave kernels and their applications

LITERATURE

[1] Grigor'yan, Heat Kernel and Analysis on Manifolds, American Mathematical Society, Providence, RI, 2009.

[2] Chavel, Riemannian Geometry: A Modern Introduction, 2nd ed., Cambridge University Press, 2006.

[3] P. E. T. Jorgensen and E. J. Pearse, Operator Theory and Analysis of Infinite Networks: Theory and Applications, World Scientific, 2023.

[4] Relevant project papers, selected in consultation with individual students.

Grading

	Criterion	Points	Cut-off points
1.	Homework	20	
2.	Project	50	
3	Final exam	30	
	Total	100	55