

## Partial Differential Equations (C000802)

**Course size** *(nominal values; actual values may depend on programme)*

**Credits 6.0** **Study time 165 h**

**Course offerings and teaching methods in academic year 2025-2026**

A (semester 1)	English	Gent	lecture
			seminar

**Lecturers in academic year 2025-2026**

Ruzhansky, Michael	WE16	lecturer-in-charge
Chatzakou, Marianna	WE16	co-lecturer
Van Bockstal, Karel	WE16	co-lecturer

**Offered in the following programmes in 2025-2026**

Master of Science in Teaching in Science and Technology (main subject Mathematics)	6	A
Master of Science in Mathematics	6	A
Exchange Programme in Mathematics (master's level)	6	A

**Teaching languages**

English

**Keywords**

PDE's, modelling, existence and uniqueness of solutions, variational approximation

**Position of the course**

This course offers an overview of vital topics, problems and solution methods in the study of partial differential equations (PDEs). The following aspects of this theory, which are of particular interest for the different options within the master of mathematics, will be treated in a balanced way: modelling of physical problems with PDEs and the qualitative analysis of elliptic, parabolic and hyperbolic PDEs. Each of the problems treated in the course will be approached from these different points of view, each time with the appropriate emphasis.

**Contents**

1. Ordinary Differential Equations (ODEs)
  - Laplace and Fourier transform method for solving ODEs
2. Basics for PDEs
  - Introduction to PDEs, well-posedness
  - Classification linear PDEs second-order: elliptic, parabolic, hyperbolic PDEs
  - Derivation of PDEs
3. Function spaces
  - Regularity of domain
  - Weak derivative
  - Sobolev spaces, embedding theorems, Green's formulas, Poincarè-Friedrichs' inequality
4. Elliptic problems
  - Harmonic functions: properties, Poisson equation, Green function ball
  - Variational framework: derivation weak formulation, existence and uniqueness weak solution (Lax-Milgram lemma), regularity solution, examples
  - Spectral method: Helmholtz equation, Sturm-Liouville eigenvalue problem
  - Galerkin method
5. Parabolic problems
  - Derivation heat equation from physical conservation laws, porous media flow
  - Maximum principle for heat operator

- Cauchy problem 1D
- Method of separation of variables for heat equation
- Rothe's method: well-posedness heat equation
- 6. Hyperbolic problems
- Derivation vibrating string
- Method of characteristics for first-order hyperbolic PDEs
- Cauchy problem 1D
- Method of separation of variables for wave equation
- Rothe's method: well-posedness wave equation
- 7. Numerical aspects

#### **Initial competences**

Mathematical analysis, linear algebra, function spaces

#### **Final competences**

- 1 The students are able to make a distinction between respectively parabolic, hyperbolic and elliptic PDEs, their respective boundary and initial conditions, and the behaviour of the solution.
- 2 The students are able to model basic physical problems with PDEs.
- 3 The students are able to apply and analyse the theoretical results for each type of PDE and to employ the classical and variational techniques for solving PDEs.
- 4 The students are able to apply basic solution methods for solving PDEs.

#### **Conditions for credit contract**

Access to this course unit via a credit contract is determined after successful competences assessment

#### **Conditions for exam contract**

This course unit cannot be taken via an exam contract

#### **Teaching methods**

Seminar, Lecture, Independent work

#### **Study material**

Type: Syllabus

Name: Syllabus'  
Indicative price: € 10  
Optional: no

Type: Other

Name: Matlab-files, Maple-worksheets and Java applets'  
Indicative price: Free or paid by faculty  
Optional: no  
Additional information: All the material will be available via Ufora.

#### **References**

Lecture notes will be provided. Other reference works are  
Principles of Mathematical Modeling - Ideas, Methods, Examples. A.A. Samarskii & A.P. Michaelov, Taylor & Francis, 2002.  
Partial Differential Equations, Methods and Applications. R.C. McOwen, Prentice Hall, 2003  
Partial differential equations. L.C. Evans, American Mathematical Society, 1998.

#### **Course content-related study coaching**

- Individual coaching by appointment
- interactive coaching via Ufora: Forum (students among themselves, students-lecturer)

#### **Assessment moments**

continuous assessment

#### **Examination methods in case of periodic assessment during the first examination period**

#### **Examination methods in case of periodic assessment during the second examination period**

#### **Examination methods in case of permanent assessment**

Participation, Presentation, Assignment

**Possibilities of retake in case of permanent assessment**

examination during the second examination period is possible

**Calculation of the examination mark**

Non-periodic evaluation 100%