

# Introduction to Scientific Computing

## Collection of Exam Questions – PDE

Classification of questions:

- regular question – could well be part of the exam;
- more difficult question;
- \* probably too difficult or extensive for the exam (if too extensive, parts of the task might be appropriate, though);
- side topic – probably not part of the exam.

The list contains only questions that were generated by the students during the lectures. Consequently, there is no guarantee that the list is complete or representative. However, the questions cover an extensive part of the lecture, and I want to thank everyone who contributed to it.

## 1 Modelling

- Write down the heat equation for one specific scenario and explain it.
- For a given solution plot, explain which kind of model was probably used (and solved). (e.g. identify boundary conditions, etc.)
- What type of boundary conditions can be found in PDE problems?
- What are Dirichlet/Neumann boundary conditions? Give a modelling example for each.
- For a discrete model, formulate the heat balance for one cell. On which values does the heat flow across the edges depend on?

- Describe the wiremesh model/the finite volume model for heat flow. (Draw and example mesh/what equation have to be solved/what boundary conditions are used)
- What is the difference between a discretised model and a discrete model?

## 2 Numerics

- What's the difference between the implicit and explicit scheme of the heat equation? What are the main advantageous/disadvantageous?
- There are point-based and cell-based discretization methods – give an example for each of them.
- What boundary/initial conditions are required for the implicit and explicit Euler scheme?
- Explain/discuss the difference between finite differences and finite elements

## 3 Heat Equation

- What are the main methods used to solve the heat equation?
- Find the equilibrium condition for a given heat equation.
- What possibilities are there to solve the time-dependent heat equation? ( $T_t = T_{xx} + T_{yy}$ )
- What's the difference between a temperature difference and a temperature gradient? (Hint: how do they change, when the mesh size is refined)
- Derive a discretisation for the 2D heat equation
- Discuss possible disadvantages of discrete models for the heat equation. Explain the alternative models.
- \* discuss the energy & stability of implicit and explicit time stepping schemes for the heat equation.
- \* Derive a solution for the 2D heat equation using the “separation of variables” approach.

## 4 Grid Generation

- What types of grids exist and which characteristics do they have?

- What different approaches to grid generation are there?
- In what scenarios are the different approaches used?
- Describe one/some of the methods used for grid generation in detail.
- What are the advantages of adaptive grids?
- What are the advantages of the different types of grids?