Area E – Numerics and Scientific Computing

Foundation in Numerical Mathematics F4E1:

- **Scientific Computing I** (Winter term)
- **Scientific Computing II** (Summer term)

Lectures of Foundation modules may be taught in German.

Core Lecture Courses:

- **V4E1 Numerical Algorithms** (Winter term)
- **V4E2 Numerical Simulation** (Summer term)

Advanced Lecture Courses:

- **V5E1 Advanced Topics in Scientific Computing**
- **V5E2 Selected Topics in Scientific Computing**
- **V5E3 Advanced Topics in Numerical Methods in Science and Technology**
- **V5E4 Selected Topics in Numerical Methods in Science and Technology**

Typical Topics treated in advanced lecture courses include for example:

- **Hierarchical Methods** (e.g. multigrid methods, hierarchical matrices)
- **Computational Finance** (e.g. option pricing, fast numerical methods)
- **Visualization Methods** (e.g. graphics and fast algorithms)
- **Iterative Solution Techniques** (e.g. multilevel preconditioning, multigrid methods, domain decomposition)
- **Boundary Element Methods** (e.g. boundary integral equations, nonlocal operators, efficient solution methods)
- **High-dimensional Problems** (e.g. curse of dimension, sparse grid methods)
- **Nonlinear Partial Differential Equations** (e.g. phase field models, geometric partial differential equations, Navier-Stokes equations, viscosity solutions, level set methods)
- **Adaptive Methods** (e.g. a posteriori error estimation, automatic mesh-refinement)
- **Image Processing** (e.g. Mumford Shah model, compression with wavelet methods, texture analysis, image restoration)
- **Shape Optimization** (e.g. duality techniques, stochastic cost functionals, topological derivatives, multi-scale optimization)

Useful supplementary courses from other areas:

- **F4B1 Functional Analysis** (Very important !)
- **F4B1 PDE and Modeling**
- **F4B1 Global Analysis I**
- **V4B1 Nonlinear PDE I**
- **F4C1 Combinatorics, Graphs, Matroids**
- **V4C2 Approximation Algorithms**
- **F4D1 Geometry**
- **F4F1 Stochastic Processes**
- **V4F1 Stochastic Analysis**

Area E – Numerics and Scientific Computing

Recommended Curricula

- In all modules in Area E, a basic knowledge of numerical analysis is assumed. A background in functional analysis and the theory of partial differential equations is helpful for some of the more advanced topics.
- If you did not take any scientific computing based course during your Bachelor studies, we recommend that you start with one of the Foundation modules “Scientific Computing” and take the core modules “Numerical Simulation’’ and “Numerical Algorithms’’ afterwards (Option I).
- If you already wrote your Bachelor thesis in Area E, you may directly start with one of the core modules “Numerical Algorithms’’ or “Numerical Simulation’’ (Option II).

Start in October:

- **Option I**
    1. Scientific Computing I
    2. Numerical Simulation
    3. Numerical Algorithms
    4. (Advanced or Selected Topics)
- **Option II**
    1. Numerical Algorithms
    2. Numerical Simulation (+ Advanced Topics)
    3. Advanced or Selected Topics
    4. (Selected Topics)

Start in April:

- **Option I**
    1. Scientific Computing II (knowledge of Scientific Computing I is required)
    2. Numerical Algorithms
    3. Numerical Simulation + Advanced Topics
    4. (Advanced or Selected Topics)
- **Option II**
    1. Numerical Simulation (knowledge of PDE and Functional Analysis and Scientific Computing is required)
    2. Numerical Algorithms (+ Advanced Topics)
    3. Advanced or Selected Topics
    4. (Selected Topics)

Example Curriculum- Major Area E – Start in October

<table>
<tr><th></th><th colspan="3">Major
(Area E)</th><th>Minor
(Area B)</th><th>Minor
(other)</th><th>Options</th></tr>
<tr><td>1</td><td colspan="2">Numerical Algorithms

9 CP</td><td>Practical Lab

9 CP</td><td>Functional Analysis and PDE

9 CP</td><td rowspan="2">e.g.

Discrete Mathematics

Geometry

Stochastic Processes

9 CP</td><td rowspan="4">e.g.

Practical Teaching Course

External Internship

Quantum Mechanics

Statistical Physics

Mathematical Finance

13 CP</td></tr>
<tr><td>2</td><td>Numerical Simula-tion

9 CP</td><td>Graduate Seminar

6 CP</td><td>Graduate Seminar

6 CP</td><td></td></tr>
<tr><td>3</td><td rowspan="2">Selected Topics

5 CP</td><td rowspan="2">Master Thesis

30 CP</td><td rowspan="2">Master Thesis Seminar

6 CP</td><td>Nonlinear PDE I

9 CP</td><td></td></tr>
<tr><td>4</td><td></td><td></td></tr>
</table>

Example Curriculum- Major Area E – Start in April

<table>
<tr><th></th><th colspan="3">Major
(Area E)</th><th>Minor
(Area B)</th><th>Minor
(Area C)</th><th>Options</th></tr>
<tr><td>1</td><td colspan="2">Numerical Simulation

9 CP</td><td>Graduate Seminar

6 CP</td><td>PDE and Modeling

9 CP</td><td></td><td rowspan="4">e.g.

Practical Teaching Course

External Internship

Quantum Mechanics

Statistical Physics

Mathematical Finance

11 CP</td></tr>
<tr><td>2</td><td>Graduate Seminar

6 CP</td><td>Numerical Algorithms

9 CP</td><td>Practical Lab

9 CP</td><td>Nonlinear PDE I

9 LP</td><td></td></tr>
<tr><td>3</td><td rowspan="2">Advanced Topics

7 CP</td><td rowspan="2">Master Thesis

30 CP</td><td rowspan="2">Master Thesis Seminar

6 CP</td><td rowspan="2"></td><td>Approximation Algorithms

9 LP</td></tr>
<tr><td>4</td><td></td></tr>
</table>