### Module title
Nonlinear Optimization

<table>
<thead>
<tr>
<th>Module code</th>
<th>Level</th>
<th>Hours per week</th>
<th>ECTS credits</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOP</td>
<td>Master (M.Sc.)</td>
<td>4 + 2</td>
<td>7.5</td>
<td>1 semester</td>
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</tbody>
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#### Module instructor
Prof. Dr. Körkel

#### Lecture type
Lecture + Tutorial/Practical

#### Prerequisite(s)
- Analysis 1,2
- Linear Algebra 1,2
- Linear Optimization
- Mathematical Software

#### Grading
- Written exam (90-120 min) or oral exam (15-45 min)

### Objectives
- Understanding of the modeling of nonlinear optimization problems
- Knowledge of important prototypes of nonlinear optimization models
- Detailed knowledge of structure and properties of important algorithms for the solution of nonlinear optimization problems
- Implementation of software modules for the solution of nonlinear optimization problems

### Content
- Optimality conditions for unconstrained and constrained problems (Lagrange, Karush-Kuhn-Tucker)
- Convex optimization problems
- Descent methods for unconstrained problems (e.g. gradient method, CG method)
- Descent methods for constrained problems (e.g. method of feasible directions, projected and reduced gradients, penalty methods)
- Newton-type methods (e.g. quasi-Newton methods, SQP methods, in particular BFGS, Gauß-Newton)
- Analysis of the local convergence behavior of the methods (i.a. Theorem of Dennis-Moré)
- Methods for the globalization of convergence (e.g line search, trust region, Theorem of Zoutendijk)
- Methods for inequality constrained problems (e.g. active set, interior point)
- Methods for the evaluation of derivatives (e.g. numerical vs. automatic differentiation)
- Application examples (especially nonlinear fitting problems)
- Algorithms and software (i.a. MATLAB)

### Textbook/teaching material
- Own lecture notes
- Nocedal, J., Wright, S. J.: Numerical Optimization
- Luenberger, D. G., Ye, Y.: Linear and Nonlinear Programming
- Geiger, C., Kanzow, C.: Numerische Verfahren zur Lösung unrestringierter Optimierungsverfahren
- Geiger, C., Kanzow, C.: Theorie und Numerik restringierter Optimierungsaufgaben
- Stoer, J., Jarre, F.: Optimierung
- Ulbrich, M., Ulbrich, S.: Nichtlineare Optimierung

Note: this is not the official course descriptor according to the "Studien- und Prüfungsordnung" (SPO)