

## Numerical Optimisation (E004160)

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

**Credits 3.0**                      **Study time 90 h**

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

A (semester 1)	English	Gent	lecture seminar
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**Lecturers in academic year 2025-2026**

Wauters, Jolan	TW08	lecturer-in-charge
Degroote, Joris	TW08	co-lecturer

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

	<b>crdts</b>	<b>offering</b>
<a href="#">Master of Science in Electromechanical Engineering(main subject Control Engineering and Automation)</a>	3	A
<a href="#">Master of Science in Electromechanical Engineering(main subject Electrical Power Engineering)</a>	3	A
<a href="#">Master of Science in Electromechanical Engineering(main subject Maritime Engineering)</a>	3	A
<a href="#">Master of Science in Electromechanical Engineering(main subject Mechanical Construction)</a>	3	A
<a href="#">Master of Science in Electromechanical Engineering(main subject Mechanical Energy Engineering)</a>	3	A

**Teaching languages**

English

**Keywords**

Optimisation, numerical methods, gradient, sensitivity, heuristics, Pareto

**Position of the course**

This course provides insight into the different numerical techniques that can optimise a design and reduce a cost. The student learns to apply these techniques to practical engineering problems.

**Contents**

**Theory:**

- 1 Formulation: design variables, objectives, constraints
- 2 Exploring the design space: design of experiments, effects, sensitivity study, visualisation
- 3 Gradient-based techniques without constraints: existence and uniqueness of the optimum, line search, steepest descent, conjugate gradient, Newton, quasi-Newton
- 4 Gradient-based techniques with constraints: Karusk-Kuhn-Tucker conditions, simplex, penalty methods
- 5 Gradient calculation: adjoint, automatic differentiation
- 6 Stochastic techniques: random search, simulated annealing, genetic algorithms, particle swarm
- 7 Surrogate-based techniques: Kriging, neural networks, space mapping
- 8 Multiple objectives: Pareto front, multi-objective evolutionary algorithms

**Exercises:**

- 1 Exploring design space for a car heat exchanger
- 2 Optimisation with and without constraints
- 3 Optimisation with and without gradient information for an electromagnetic actuator
- 4 Calculating the gradient for heat conduction in a bar
- 5 Optimisation with deterministic and stochastic methods for a switched reluctance motor

**Initial competences**

### Final competences

- 1 Describe common numerical optimisation techniques.
- 2 Select appropriate numerical optimisation techniques for an engineering problem.
- 3 Apply numerical optimisation techniques to an engineering problem.

### 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

### Study material

Type: Slides

Name: Capita selecta from English books. Slides. Free of charge.

Indicative price: Free or paid by faculty

Optional: no

### References

[1] Jorge Nocedal, Stephen Wright. Numerical Optimization. Second Edition, Springer, New York, 2006.

[2] Panos Papalambros, Douglass Wilde. Principles of Optimal Design: Modeling and Computation. Cambridge University Press, New York, 2000.

[3] Kaj Madsen, Hans Bruun Nielsen. Introduction to Optimization and Data Fitting. 2008.

### Course content-related study coaching

- the electronic learning environment
- Possibility of appointments for additional explanation

### Assessment moments

end-of-term and continuous assessment

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

Written assessment

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

Written assessment

### Examination methods in case of permanent assessment

Assignment

### Possibilities of retake in case of permanent assessment

examination during the second examination period is possible

### Extra information on the examination methods

- Periodic (end-of-term) evaluation: written examination with closed book. Second evaluation: written examination with closed book.
- Permanent evaluation: assessment of project report. Frequency: 1 report.

### Calculation of the examination mark

- Periodic (end-of-term) evaluation 50%, permanent evaluation 50%
- Special condition: If the student scores less than 8/20 for at least one component of the assessment, a pass mark for the course unit in question is not possible. If the final mark does turn out to be a 10/20 or more, this will be reduced to the highest non-deliberative mark, i.e. 7/20.