GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2024-2025

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

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	**crdts**	**offering**
Master of Science in Electromechanical Engineering(main subject Control Engineering and Automation)	3	A
Master of Science in Electromechanical Engineering(main subject Electrical Power Engineering)	3	A
Master of Science in Electromechanical Engineering(main subject Maritime Engineering)	3	A
Master of Science in Electromechanical Engineering(main subject Mechanical Construction)	3	A
Master of Science in Electromechanical Engineering(main subject Mechanical Energy Engineering)	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

Introduction to numerical mathematics

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.