GHENT UNIVERSITY

# Course Specifications

Valid as from the academic year 2024-2025

## Mathematics in Photonics (E002640)

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

**Credits 4.0** **Study time 120 h**

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

| | | | |
|---|---|---|---|
| A (semester 1) | English | Gent | seminar |

**Lecturers in academic year 2025-2026**

| | | |
|---|---|---|
| Bienstman, Peter | TW05 | lecturer-in-charge |

| **Offered in the following programmes in 2025-2026** | **crdts** | **offering** |
|---|---|---|
| Bridging Programme Master of Science in Photonics Engineering | 4 | A |
| Master of Science in Photonics Engineering | 4 | A |

**Teaching languages**

English, Dutch

**Keywords**

applied mathematics, photonics

**Position of the course**

Exposing the student to various mathematical concepts often used in photonics. The aim is to make the student acquainted with the basic principles and references, in order to allow him to independently further research these concepts.

**Contents**

- 1: Complex analysis: wave problems as problems from complex analysis, complex functions, analytic functions, derivatives, line integrals, poles, zeros, branch cuts, residue calculus, limit theorems, Cauchy principal value, Kramers-Kronig dispersion relation, conformal transformations, bend losses in optical waveguides. Supplement: Kramers-Kronig receivers.
- 2: Special functions: modes of an optical fibre, Bessel and Neuman functions, generating functions, recursion relations, integrals, orthogonality, series expansion, higher order solutions of the paraxial wave equation, Hermite polynomials, generating function, recurrence relation, differential equation, orthogonality, series expansion
- 3: Numerical techniques: finite elements, finite differences, variational methods, eigenmode expansion, method of weighted residuals
- 4: Periodicity and symmetry in photonic systems: using symmetries to classify modes, Bloch theorem, band diagrams, photonic crystals
- 5: Dynamical systems: origins of non-linearity in optical systems, stability, fixed points, the logistic map, saddle points, bifurcations, chaos, period doubling, Lyaponov exponent, stable and unstable manifold

**Initial competences**

mathematics from the bachelor program

**Final competences**

1 being able to apply complex analysis to photonic problems
2 being able to apply special functions and orthogonal polynomials to photonic problems
3 getting a basic insight in the effects of symmetry on photonic systems
4 getting a basic insight into numerical techniques for photonics
5 being able to study the dynamics of a photonic system
6 being able to study a new mathematical topic in an independent and critical manner and apply it in a creative way

**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, Independent work

**Study material**

Type: Handouts

Name: full lecture notes
Indicative price: Free or paid by faculty
Optional: no
Additional information: free of charge

Type: Audiovisual Material

Name: Videos
Indicative price: Free or paid by faculty
Optional: no

**References**

**Course content-related study coaching**

**Assessment moments**

end-of-term and continuous assessment

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

Oral assessment open-book

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

Oral assessment open-book

**Examination methods in case of permanent assessment**

Participation

**Possibilities of retake in case of permanent assessment**

examination during the second examination period is possible

**Calculation of the examination mark**