GHENT UNIVERSITY

Course Specifications

Valid in the academic year 2023-2024

Plasma Physics (E026221)

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

Credits 6.0 **Study time 180 h**

Course offerings and teaching methods in academic year 2023-2024

A (semester 1)	English	Gent	seminar lecture practical
B (semester 1)	Dutch	Gent	

Lecturers in academic year 2023-2024

Verdoolaege, Geert	TW17	lecturer-in-charge

Offered in the following programmes in 2023-2024	crdts	offering
Master of Science in Teaching in Science and Technology(main subject Physics and Astronomy)	6	A
Bridging Programme Master of Science in Engineering Physics	6	A
Master of Science in Electromechanical Engineering(main subject Control Engineering and Automation)	6	A
Master of Science in Electromechanical Engineering(main subject Electrical Power Engineering)	6	A
Master of Science in Electromechanical Engineering(main subject Maritime Engineering)	6	A
Master of Science in Electromechanical Engineering(main subject Mechanical Construction)	6	A
Master of Science in Electromechanical Engineering(main subject Mechanical Energy Engineering)	6	A
European Master of Science in Nuclear Fusion and Engineering Physics	6	A
Master of Science in Engineering Physics	6	B
Master of Science in Engineering Physics	6	A
Master of Science in Physics and Astronomy	6	A
Exchange Programme in Physics and Astronomy (Master's Level)	6	A

Teaching languages

English, Dutch

Keywords

Motion of charged particles, magnetohydrodynamics (MHD), waves and solitons, transport processes, plasma instabilities, kinetic theory, gas discharges, industrial plasmas, space plasmas, astrophysical plasmas, controlled thermonuclear fusion

Position of the course

Plasmas, gases with charged particles, represent by far the most common phase of matter in the universe. Stars, nebulae and interstellar space are permeated by plasmas, while planetary plasmas occur in lightning and the magnetosphere. In addition, plasmas have many technological applications, e.g. for semiconductor device fabrication, surface treatment, environmental and medical applications, etc. Another major application area is controlled thermonuclear fusion research, aiming at sustainable energy production in magnetically or inertially confined plasmas.

This course provides an introduction to the physical concepts and tools needed to describe a large variety of plasmas observed in nature and used for practical applications. The key difference with neutral gases lies in the collective behaviour of plasmas owing to interaction of the charged particles with internal and external electric and magnetic fields. As a result, a fluid description of plasmas is appropriate under some circumstances, while in other cases a treatment based on kinetic theory is required. Introducing the basic plasma concepts, motion of charged particles in electric and magnetic fields, the magnetohydrodynamic equations, transport and instabilities, as well as the statistical kinetic description, the course allows students to practice their skills in applying a wide variety of basic physical theories, while preparing them for a possible more in-depth study of this rich domain of physics.

Contents

- Basic concepts of plasmas
- Single-particle motion in electric and magnetic fields
- Plasmas as fluids, magnetohydrodynamics
- Waves in plasmas (electrostatic, electromagnetic and acoustic waves)
- Collisions, diffusion and resistivity
- Equilibrium and stability, plasma instabilities
- Plasma kinetic theory
- Nonlinear effects (plasma sheaths, shock waves, solitons)
- Special plasmas (ultracold plasmas, dusty plasmas, atmospheric-pressure plasmas)
- Plasma engineering applications (semiconductor etching, surface treatment, spacecraft propulsion, fusion energy)

Initial competences

Vector calculus, classical mechanics, electrodynamics, statistical physics

Final competences

1 Have a thorough understanding of the important physical theories in the field of plasma physics.
2 Understand the role of plasmas in natural phenomena and technological applications.
3 Select and apply the proper models, methods and techniques to solve plasma physics problems.
4 Conduct and understand simple experiments with plasmas and report on the experimental findings, both orally and in writing.

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, Practical, Independent work

Extra information on the teaching methods

The basis of the course is the textbook by F.F. Chen. The course material is taught in the theory classes (24 hrs) and supplemented with problem solving (8 hrs) and guided self-study using the textbook. A series of lab sessions (8 hrs) will serve as permanent evaluation.

Learning materials and price

- Textbook (compulsory): F.F. Chen, Introduction to Plasma Physics and Controlled Fusion, 3rd ed., Springer, 2016, ISBN 978-3319223087. Free for download from the publisher's website.
- Slides

References

- J.P. Freidberg, Plasma Physics and Fusion Energy, Cambridge University Press, 2008. ISBN 978-0521733175
- Yu.P. Raizer, Gas Discharge Physics, Springer, 2011. ISBN 978-3642647604

Course content-related study coaching

The instructors can be contacted after the lectures, or by appointment. Interactive support via the electronic learning platform.

Assessment moments

end-of-term and continuous assessment

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

Written assessment open-book, Written assessment

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

Written assessment open-book, Written assessment

Examination methods in case of permanent assessment

Assignment

Possibilities of retake in case of permanent assessment

not applicable

Extra information on the examination methods

End-of-term assessment:

- Theory: written examination (closed book)
- Exercises: written examination (open book)

Continuous assessment: 2 lab sessions en 1 programming exercise with written report

Calculation of the examination mark

- Theory examination: 50%
- Problems examination: 25%
- Lab reports: 25%. The scores for the lab sessions can be copied to the resit period.