GHENT UNIVERSITY

# Course Specifications

Valid in the academic year 2024-2025

## Dynamics: from Newton to Schrödinger (C004517)

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

**Credits 6.0** **Study time 180 h**

**Course offerings in academic year 2024-2025**

A (semester 1) English Gent

**Lecturers in academic year 2024-2025**

| | | |
|---|---|---|
| De Rijcke, Sven | WE05 | lecturer-in-charge |

| Offered in the following programmes in 2024-2025 | crdts | offering |
|---|---|---|
| Master of Science in Physics and Astronomy | 6 | A |
| Exchange Programme in Physics and Astronomy (Master's Level) | 6 | A |

**Teaching languages**

English

**Keywords**

Dynamics, theoretical mechanics, variational principles, symmetries and conserved quantities, historical background.

**Position of the course**

The historical evolution from a Newtonian to a Lagrangian, a Hamiltonian, and, finally, a quantum mechanical description of dynamics is characterized by generalizing the underlying principles of the existing theories: the principle of virtual work, d'Alembert's principle, the principle of least action. Parallel to this, the notion of a "coordinate" has been extended (from spatial coordinates, to Lagrange's generalized coordinates, to Hamilton's phase space of generalized coordinates and momenta. These parallel evolutions led to better insights into dynamical systems, and cleared the path from classical to quantum mechanics (as formulated by Schrödinger and Feynman).
This course builds on and extends the material covered in the course "Theoretische Mechanica". Although this course also looks into applications of the theory, it focuses mostly on the underlying theoretical principles, their physical meaning, and how they are connected and how they are derived from each other. This course bridges the courses "Theoretische Mechanica" "Statistische fysica" "Algemene relativiteitstheorie" and "Kwantummechanica I"

**Contents**

- Newtonian mechanics
- the principle of virtual work and the principle of d'Alembert
- least action and Lagrangian mechanics
- phase space and Hamiltonian mechanics
- the distribution function, Liouville's equation, statistical physics
- canonical transformations
- Hamilton-Jacobi theory, separation of variables, action-angle variables
- symmetries and conservation laws (Noether)
- chaos theory: KAM theorem, Poincare sections, chaotic orbits
- Hamilton and the analogy to geometric optics: the road to the Schrödinger equation
- Feynman's path integrals, Schrödinger's equation, and the action principle

**Initial competences**

This course build on "Theoretische Mechanica" "Statistische fysica", "Algemene relativiteitstheorie" and "Kwantummechanica I". Students should have successfully

taken these courses or have acquired the skills put forward in these courses in another way.

**Final competences**

1 Understand the physical and mathematical basic principles of the different formulations of dynamics
2 insights in the conceptual and historical ties between the different formulations of dynamics
3 Be able to use the theories covered in the course, to make qualitative and/or quantitative predictions regarding the behaviour of dynamical systems
4 insights in the limitations of the theories covered in the course
5 Appreciate the philosophical and societal importance of the topic and be able to translate this to the non-expert

**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

**Extra information on the teaching methods**

Students are expected to solve the problem sets at the end of each chapter. Two students will present their solutions to their peers during an exercise session. This allows the students to hone their presentation skills for a friendly audience, to learn from each other, and to compare different approaches to the problems.

**Study material**

Type: Syllabus

Name: Syllabus
Indicative price: Free or paid by faculty
Optional: no
Additional information: downloadable from Ufora as a .pdf file

Type: Slides

Name: Lectures slides
Indicative price: Free or paid by faculty
Optional: no

**References**

**Course content-related study coaching**

interactive support via Ufora, personal support: on appointment

**Assessment moments**

end-of-term assessment

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

Oral assessment, Written assessment, Assignment

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

Oral assessment, Written assessment, Assignment

**Examination methods in case of permanent assessment**

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

not applicable

**Extra information on the examination methods**

theory: part written exam, part oral exam
exercises: open book exam

**Calculation of the examination mark**

theory exam : 12/20
exercise exam : 8/20