GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2024-2025

Continuum Mechanics (E040430)

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 2024-2025

A (semester 2)	English	Gent	independent work
			lecture

Lecturers in academic year 2024-2025

Verdoolaege, Geert	TW17	lecturer-in-charge

Offered in the following programmes in 2024-2025	**crdts**	**offering**
European Master of Science in Nuclear Fusion and Engineering Physics	6	A
Master of Science in Physics and Astronomy	6	A

Teaching languages

English

Keywords

Continuous media, differential geometry, tensors, elasticity, fluid mechanics, viscosity, turbulence, waves, plasmas, magnetohydrodynamics, general relativity, cosmology

Position of the course

Continuum mechanics is a broad and interdisciplinary field, embracing the mechanics of elastic media and fluids (liquids, gases and plasmas), but also aspects of cosmology and the relativistic continuum (space-time). The objective of the course Continuum Mechanics is essentially twofold:

- Provide the student, starting from first principles, with insight in the physical phenomena within the rich domain of the mechanics of continuous media. The interdisciplinary character of continuum mechanics is emphasized, links between the subsdiciplines are clarified and ample attention is paid to applications that will appeal to a broad audience of physicists, mathematicians and engineers. In doing so, the necessary basic knowledge, skills and mathematical attitudes are conveyed to the students, allowing them to commence more advanced studies in each of the discussed subdisciplines.
- Equip the student with a modern mathematical framework allowing an integrated study of continuous media. In particular, strong attention is paid to the formalism of tensor calculus, pursuing deep understanding and at the same time providing experience with practical applications of tensors. Hence, the course brings students into contact with several widely used concepts from theoretical physics, although mostly in a context of everyday phenomena and applications.

Contents

The following subjects are treated in the course:

- Basic concepts regarding Cartesian tensors, Lagrangian and Eulererian coordinates
- Strain tensor, deformation, conservation laws, constitutive equations
- Linear elasticity, Navier equations
- Newtonian fluid mechanics, Navier-Stokes equations, ideal fluids, vorticity
- Viscous fluids, laminar flow, turbulent flow, boundary layer, aerodynamics
- Thermodynamics of continua
- Applications of the Euler equations: solar wind, stellar stability, Newtonian

cosmology
- Waves and solitons (Korteweg-de Vries)
- Electromagnetic continuum in plasmas, magnetohydrodynamics (MHD), plasma waves
- Concepts from modern differential geometry: vector fields and differential forms, tensor analysis, Riemannian geometry
- Nonlinear continua
- Structural elements: beams, plates and shells
- Geometry and gauge theory in fluid mechanics
- Relativistic continuum, energy-momentum tensor, Einstein field equations, cosmology

Initial competences

The students dispose of the necessary basic knowledge about linear algebra, mathematical analysis (vector analysis) and physics (Newtonian and theoretical mechanics, electromagnetics, special relativity, etc.)

Final competences

1 The student has gained insight in the foundations of the mechanics of continuous media.
2 The student has gained appreciation for the interdisciplinary character of the domain of continuum mechanics and of the common applicability of the underlying physical principles and the mathematical formalism in the multiple specialties wherein applications were provided.
3 The student is able to use the acquired expertise to translate physical problems into mathematical models and, conversely, to interpret mathematical conclusions in a physical context.
4 The student has acquired arithmetic skills, both analytical and by computer, allowing him/her to solve new problems in continuum mechanics, starting from the insight gained.
5 The student has acquired the necessary skills enabling him/her to commence a more specialized study in each of the subdisciplines discussed.

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, Peer teaching

Extra information on the teaching methods

The teaching methods mainly consist of plenary lectures (theory classes) and in-class problem solving. This is supplemented by guided self-study using the course notes.
Part of the subject matter is taught via the "flipped classroom" principle. Students receive a number of assigments asking them to prepare part of the subject matter individually and write a short report about it. This is followed by a brief presentation in class.
Use of the electronic learning environment for dissemination of general information related to the course, the exercises and the assignments.

Study material

Type: Syllabus

Name: Continuum Mechanics
Indicative price: Free or paid by faculty
Optional: no
Language : English
Number of Pages : 255
Oldest Usable Edition : 2023-2024
Available on Ufora : Yes
Online Available : No
Available in the Library : No
Available through Student Association : No

Type: Slides

Name: Continuum Mechanics
Indicative price: Free or paid by faculty
Optional: no
Language : English
Number of Slides : 492
Oldest Usable Edition : 2023-2024
Available on Ufora : Yes
Online Available : No
Available in the Library : No
Available through Student Association : No

References

- B. Lautrup, Physics of Continuous Matter, Second Edition, CRC Press, 2011, ISBN 978-1-4200-7700-1.
- T.J. Chung, General Continuum Mechanics, Cambridge University Press, 2007, ISBN 978-0-521-87406-9.
- A. Romano and A. Marasco, Continuum Mechanics using Mathematica: Fundamentals, Methods and Applications, Birkhäuser, 2nd edition, 2014, ISBN 978-1-4939-1603-0.
- J.E. Marsden and T.J.R. Hughes, Mathematical Foundations of Elasticity, Dover Publications, 1994, ISBN 978-0486678658.

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

Oral assessment, Written assessment open-book, Written assessment

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

Oral assessment, Written assessment open-book, Written assessment

Examination methods in case of permanent assessment

Presentation, Assignment

Possibilities of retake in case of permanent assessment

not applicable

Extra information on the examination methods

The report and presentation in the context of the "flipped classroom" are marked and count towards 20% of the examination result.
The examination consists of a theory and exercises part.
Theory: written preparation (closed book) with oral discussion. Insight in the subject matter is emphasized, rather than pure reproduction.
Exercises: written, open book.

Calculation of the examination mark

Flipped classroom: 20%
Examination theory: 40%
Examination exercises: 40%