UCLouvain

lmeca2771 — Thermodynamics of irreversible phenomena.

2025

The version you're consulting is not final. This course description may change. The final version will be published on 1st June.

5.00 credits	30.0 h + 30.0 h	Q2

Teacher(s)	Papalexandris Miltiadis ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Prerequisites	It is expected that the students have mastered the basics of thermodynamics, as covered in the courses LMECA1855 or LPHYS1343, as well as the basics of fluid mechanics, as covered in the courses LMECA1321 or LPHY1213.
Main themes	• Elaboration of a general theoretical framework of irreversible phenomena having as starting points the kinetic theory of gases and classical thermodynamics • Presentation of the classical theory of Onsager-Prigogine. Presentation of more recent theories such as Rational Thermodynamics (theory of Truesdell & Noll) and Extended Thermodynamics (theories of Jou & Lebon and of Müller).
Learning outcomes	**At the end of this learning unit, the student is able to :** With respect to the reference AA of the programme of studies "Masters degree in Mechanical Engineering", this course contributes to the development and acquisition of the following skills • AA1.1, AA1.2, AA1.3 • AA2.1, AA2.2, AA2.3 • AA3.1, AA3.3 • AA5.1, AA5.2, AA5.6 1 • AA6.1, AA6.2, AA6.3, AA6.4 **Specific learning outcomes of the course** • A modern approach to non-equilibrium thermodynamics. • Unified description of thermal, mechanical, viscous, and electromechanical processes in order to enchance the student's synthetic skills. • Application of theoretical results in the modelling of irreversible phenomena in fluid and solid mechanics, geophysics, etc.
Evaluation methods	• i) Exam. The exam consists of exercises. It is written, with open books and notes, • ii) 3 homework assignments. • The grade on the exam counts for 70% of the overall grade on the course. The grade on each assignment counts for 10% of the overall grade on the course. Overall = 0.7 exam + 0.1 HW1 + 0.1 HW2 + 0.1 HW3 • The grades on the homework assignments count for the August session too. • We maintain the right to ask a student for an oral exam in case of technical problems or suspicion of fraude. • Failure to comply with the methodological guidelines defined on moodle, particularly with regard to the use of online resources or collaboration between students, will result in an overall mark of 0 for all hoemwork assignment. • The use of artificial intelligence tools for the homework assignments or the exam is prohibited.
Teaching methods	• Course lectures • Sessions of exercises • Lectures in the classroom with physical presence.
Content	1. Summary of equilibrium thermodynamics: first thermodynamic axiom (principle of energy conservation), absolute temperature and entropy, second axiom of thermodynamics, Gibbs relation, equations of Euler & Duhem, thermodynamic potentials and Legendre transformations, stability of equilibrium states, evolution principles, thermochemistry. 2. Classical theory of irreversible thermodynamics (theory of Eckart-Onsager-Prigogine): local equilibrium, balance laws and constitutive relations, entropy production, thermodynamic fluxes and forces, Onsager-Casimir reciprocal relations. Applications: Fourier-Navier-Stokes equations for Newtonian fluids, thermodiffusion. 3. Study of thermo-electric phenomena: Hall effect, Seebeck and Peltier effects, Nerst and Ettinghausen effects, Joule and Thomson heats.

	4. Kinetic theory of gases. Derivation of the Boltzmann equation. Collision operator. Relations between mascroscopic variables and kinetic theory. H-theorem. Collision invariants, Maxwell-Boltzmann distribution and derivation of balance laws. Justification of local equilibrium hypothesis. Theory of fluctuations of Einstein. Derivation of the Onsager-Casimir reciprocal relations. 5. Introduction to rational thermodynamics. material memory, objectivity, Clasius-Duhem inequality, material-frame indifference, constitutive relations. Application in thermo-elastic materials, comparison with the linear theory of Eckart-Onsager-Prigogine. Liu's method of Lagrange multipliers and extended theories. 6. Stationary states: criteria for minimum of entropy production and minimum of dissipated energy. Introduction to stability theory. Rayleigh-Bénard instability.
Inline resources	https://moodle.uclouvain.be/course/view.php?id=818
Bibliography	• G. Lebon, D. Jou & J. Casas-Vasquez, *Understanding Non-equilibrium Thermodynamics*, Springer, 2008. **Mandatory,** available on the e-books of the library in electronic form. • D. Kondepudi & I. Prigogine, *Modern Thermodynamics*, Wiley, 1999. **Recommended**. • S.R. De Groot and P. Mazur, *Non-equilibrium Thermodynamics*, Dover, 1984. **Recommended**.
Faculty or entity in charge	MECA

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Mechanical Engineering	MECA2M	5		
Master [120] in Electro-mechanical Engineering	ELME2M	5		
Master [120] in Mathematical Engineering	MAP2M	5		
Master [120] in Physics	PHYS2M	5		
Master [120] in Energy Engineering	NRGY2M	5		