UCLouvain

lmeca2771

2020

Thermodynamics of irreversible phenomena.

Due to the COVID-19 crisis, the information below is subject to change, in particular that concerning the teaching mode (presential, distance or in a comodal or hybrid format).

5 credits	30.0 h + 30.0 h	Q2

Teacher(s)	Papalexandris Miltiadis ;
Language :	English
Place of the course	Louvain-la-Neuve
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).
Aims	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. - - - - *The contribution of this Teaching Unit to the development and command of the skills and learning outcomes of the programme(s) can be accessed at the end of this sheet, in the section entitled “Programmes/courses offering this Teaching Unit”.*
Evaluation methods	**Due to the COVID-19 crisis, the information in this section is particularly likely to change.** • Written exam, with open books and notes. The score on the exam counts for 70% of the overall score (grade) on the course. • 3 homework assignments. The score on each assignment counts for 10% of the overall score (grade) on the course. • We maintain the right to ask a student for an oral exam in case of technical problems or suspicion of fraude.
Teaching methods	**Due to the COVID-19 crisis, the information in this section is particularly likely to change.** • Course lectures • Sessions of exercises • Lectures in the classroom or mixed (classrooms with simultaneous broadcasting on Teams) depending on the pandemic conditions
Content	1. Summary of equilibrium thermodynamics: first thermodynamic axiom (principle of energy conservation), absolute temperature and entropy, second thermodynamic axiom, 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	http://moodleucl.uclouvain.be/enrol/index.php?id=6793
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

Force majeure

Teaching methods	Due to the pandemic, the class lectures and exercise sessions will take place on line, via Teams.
Evaluation methods	If the exam cannot take place in an auditorium for sanitary reasons, the exam will take place on line, via Teams. It will be of duration of 3 hours, open notes and books and monitoring via webcam.

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Aims
Master [120] in Electro-mechanical Engineering	ELME2M	5		
Master [120] in Mathematical Engineering	MAP2M	5		
Master [120] in Physics	PHYS2M	5		
Master [120] in Mechanical Engineering	MECA2M	5		