UCLouvain

lmeca2322

2020

Fluid mechanics and transfer II

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	Q1

Teacher(s)	Duponcheel Matthieu ;Winckelmans Grégoire ;
Language :	English
Place of the course	Louvain-la-Neuve
Main themes	• Compressible flows. • Isentropic flows (subsonic and supersonic) in ducts with varying cross-section, shocks. • Hydrodynamic stability (Rayleigh, Orr-Sommerfeld) and transition. • Turbulence (in general, in pipes/channels, in boundary layers). • Closure models. • Practical evaluation of friction and heat transfer coefficients. • Singular head losses. • Natural convection. • Boussinesq approximation. • Phase changes (condensation, ebullition, solidification, fusion). • Heat exchangers. • Thermal radiation (physical principles; surface radiation; radiation in gases).
Aims	In consideration of the reference table AA of the program "Masters degree in Mechanical Engineering", this course contributes to the development, to the acquisition and to the evaluation of the following experiences of learning: • AA1.1, AA1.2, AA1.3 • AA2.1, AA2.2, AA2.3, AA2.4, AA2.5 • AA3.1, AA3.2 • AA4.1, AA4.2, AA4.3, AA4.4 • AA5.4, AA5.5, AA5.6 • AA6.1, AA6.2 1 This course follows the course " Fluid mechanics and transfers I ", with which it covers the basic contents in both disciplines. The courses I et II form an ensemble, and their objectives are commun : integration of fluid mechanics and transfers; physical observation and phenomenological approach; rigorous mathematical developments (conservation equations, models); important place reserved to the proper coverage of turbulence. The organisation of the courses I and II is done in such a way that the foundations are covered in course I and the more specific matters are covered in course II (e.g., compressible flows, turbulence, radiation, pratical applications, 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.** The final note of the student takes into account the notes obtained for the homeworks and the laboratories, and the note obtained for the written exam. In case of doubt about the note to attribute or of suspicion of fraud, the professors reserve the right to also interrogate the student orally.
Teaching methods	**Due to the COVID-19 crisis, the information in this section is particularly likely to change.** Lectures : there are typically 13 lectures in class, each of 2 hours. There are sessions of exercices in class and with a teaching assistant, a few homeworks (each to be done within a specified time frame), and laboratories (conducted in small groups and following a specified schedule). The homeworks and the laboratories are mandatory, and a report must be produced for each. The exercises are either direct appplications of the theory (with an objective to familiarize the student to pratical computation methods, and to typical orders of magnitude), or they rely on the student using the concepts learned in the course to tackle new problems or methodologies not explicitely studied during the lectures.
Content	**Compressible flows (7 hrs)**

	Compressible flows : Bernoulli's equation for isentropic flows; relation between incompressible flow and compressible flow at low Mach number. Isentropic flows in duct with varying cross-section, subsonic and supersonic (converging, diverging, nozzle); maximum mass flow rate. normal shock and jump relations (Hugoniot). Operating modes of a convergent-divergent nozzle. Adiabatic flow in duct with constant cross-section and with wall friction (Fanno). **2D incompressible and irrotational flows (5 hrs)** Fundamental monopole singularities: circulation singularity, mass flow rate singularity. Multipole singularities. Obtaining flows using the complex potential f(z) and examples of simple flows. Flow with and without circulation past a circular cylinder. Conformal transformation, flow past an airfoil (using the Joukowski transformation) et Kutta-Joukowski condition for the circulation, lift and Blasius theorem. **Evaporation (2 hrs)** Mass transfer in boundary layers for a highly diluted binary mixture, and correlations. Evaporation of a liquid. Heat and mass transfer correlation in forced convection, in laminar and turbulent flows. **Heat exchangers (5 hrs)** Main configurations of exchangers, incidence of the fluid circulation directions (co-flow, counter-flow and cross-flow). Convective and conductive thermal resistance. Determination of the global heat transfer coefficient. Evaluation of the exchange area. LMTD method. Efficiency of an exchanger. Dimensionless solutions epsilon-NTU (efficiency - number of transfer units). **Boiling and consensation (2 hrs)** Boiling: the different boiling modes, nucleation, Nukiyama curve; ebullition in forced convection. Condensation: film condensation, Nusselt theory. **Radiative heat transfer (5 hrs)** Basic physical laws. Surface properties (emissivity and absorbtivity, directional vs hemispherical, spectral vs total). Exchange between black surfaces. View factors. Exchange between real surfaces (special cas of gray diffuse surfaces). Electric analogy of the equivalent resistance network.
Inline resources	http://moodleucl.uclouvain.be/enrol/index.php?id=8509
Bibliography	• T. Bergman, A. Lavine, F. Incropera, D. Dewitt, Fundamentals of Heat and Mass Transfer, 8th Edition, Wiley, 2018 (recommended) • G.K. Batchelor, "An introduction to fluid dynamics", Cambridge University Press 1967 (reprinted paperback 1994). • F. M. White, "Viscous fluid flow" second edition, Series in Mechanical Engineering, McGraw-Hill, Inc., 1991. • P. A. Thompson, "Compressible-fluid dynamics", advanced engineering series, Maple Press, 1984. • H. Lamb, "Hydrodynamics", sixth edition, Cambridge University Press 1932, Dover Publications (paperback). • L. Rosenhead, "Laminar boundary layers", Oxford University Press 1963, Dover Publications (paperback). • P. G. Drazin and W. H. Reid, "Hydrodynamic stability", Cambridge University Press 1985. • M. Van Dyke, "An album of fluid motion", The Parabolic Press, 1982. • A. Bejan, "Heat transfer", Wiley, 1993. • R.B. Bird, W.E. Stewart., E.N. Lighfoot , "Transport phenomena", Wiley int. ed., 1960. • Schlichting, "Boundary-layer theory", Mc Graw-Hill, NY, 1986. • L. Prandtl and O.G. Tietjens, "Fundamentals of hydro- and aero-mechanics", Dover, NY, 1957. • J. Happel and H. Brenner, "Low Reynolds number hydrodynamics", Noordhoff int. publ., Leyden, 1973. • D.J. Tritton, "Physical fluid dynamics", Clarendon Press, 1988. • T. Bergman, A. Lavine, F. Incropera, D. Dewitt, Fundamentals of Heat and Mass Transfer, 7th Edition, Wiley, 2011**(conseillé)** • M. N. O'zisik, Heat Transfer, a Basic Approach, McGraw-Hill, 1985 • Y. Cengel, Heat Transfer, a Practical Approach, 2nd Edition, McGraw-Hill, 2003 • N. Todreas & M. Kazimi, Nuclear Systems, Volume 1, Thermal Hydraulics Fundamentals, 2nd Edition, CRC Press, 2011 • M. F. Modest, Radiative Heat Transfer, 2nd Edition, Academic Press, 2003
Faculty or entity in charge	MECA

Force majeure

Teaching methods	The lectures are given either live using videoconferencing or using prerecorded podcasts accompanied by live Q&A sessions. The exercise session are given live using videoconferencing and/or with prerecorded videos. The labs are replaced by virtual labs, given as homeworks.
Evaluation methods	The final note of the student takes into account the notes obtained for the homeworks and the virtual laboratories, and the note obtained for the written exam (MCQ and/or open questions) performed remotely.

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Aims
Master [120] in Electro-mechanical Engineering	ELME2M	5		
Master [120] in Mechanical Engineering	MECA2M	5		