UCL Université catholique de Louvain

LMECA2322

2012-2013

Fluid mechanics and transfer II.

5.0 credits	30.0 h + 30.0 h	1q

Teacher(s) :	Dupret François ; Winckelmans Grégoire ;
Language :	Français
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 :	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”.*
Content :	1.Solutions for compressible flows with simplification hypotheses (5 hrs) - Compressible flows with energy hypotheses : isentropic case, isothermal case; Bernoulli's equation; relation between incompressible flows and compressible flows al low Mach number (1,5 hrs). - Isentropic flows in duct with varying cross-section, subsonic and supersonic (converging, diverging, nozzle); maximum mass flow (1,5 hrs). - Adiabatic flow in duct with constant cross-section and with wall friction (Fanno) (1 hr). - Weak compression (isentropic): acoustic wave; strong compression (non isentropic): normal shock, jump relations (Hugoniot) (1 hr). 2. Hydrodynamic stability (1 hr) Examples of instabillities; perturbation of a base flow and linearisation : equation of Orr-Sommerfeld, stability curves for the boundary layer and for the channel flow; inviscid instability (Rayleigh) and application to the shear layer. 3. Turbulence (6 hrs) - Transition from laminar to turbulent flow: phenomenological description; turbulent pipe/channel flows and turbulent boundary layers : power law velocity profiles, mixing length model and effective viscosity model, universal velocity profile (von Karman, Prandtl) in the wall region and in the region away from the wall, buffer zone (logarithmic); temperature profiles and Reynolds analogy; friction coefficients and heat transfer coefficient (4 hrs). - Turbulence "in general": energy spectrum for homogeneous isotropic turbulence; Reynolds-averaged equations and simple closure models (2 hrs). 4. Practical evaluation of transfer coefficients (2 hrs) - Head losses in smooth and rough pipes and channels, singular head losses (vannes, sudden expansion, elbows, etc.), circuits. - Hydraulic diameter and correlations. - Evaluation of heat transfer coefficients. 5. Natural convection (3 hrs) - Boussinesq approximation. - Vertical plate: phenomenology, dimensional analysis, integral approach (constant temperature wall, laminar flow), correlations. - Confined spaces with horizontal thermal gradient : short tube, long tube, enclosure. - Confined spaces with vertical thermal gradient : Benard cells. 6. Phase changes (4 hrs) - Condensation: film condensation : Nusselt theory; complex configurations (phenomenology, correlations), binary mixtues (2 hrs). - Ebullition : the different modes of ebullition, nucleation, graphs of Nukiyama; ebullition in forced convection, binary mixtures (1 hr). - Solidification, fusion (1 hr). 7. Heat exchangers (5 hrs) - Principal configurations of exchangers, incidence of fluid circulation directions; evaluation of exchange area; efficiency of an exchanger, dimensionless solutions (number of transfer units) (2 hrs). - Liquid-liquid exchangers (with tubes, with plates) (1 hr).

	- Cooling fins, fin efficiency; gas-liquid exchangers (2 hrs). - Other types of exchangers (gas-gas), caloducs. 8. Thermal radiation (4 hrs) - Basic physical laws. - Surface properties. - Exchange between black surfaces, area of direct exchange (form factor, particular 2-D case). - Exchange between real surfaces. - Radiation of gases (in absence of dispersion).
Other infos :	Prerequisite : Fluid mechanics and transfers I (MECA 2321). Practical exercices and laboratories : - These include class sessions and laboratory sessions . - The exercices will consist in direct applications of the theory (the objective being to initiate the student to practical calculation procedures and to the proper orders of magnitudes), in exercices requiring further creativity to extend the approaches covered in class (the objective being to use the concepts covered in class and to apply them to other objets or in the framework of other methods). - Measurement laboratory(ies) will be organized to confront the student to the practical and physical aspects of fluid mechanics and transfers, to the measurement techniques (methods, constraints, precision) and to the order of magnitude of the measured quantities. The personal implication of the student will be significant, while recognizing that they cannot be fully autonomous with respect to some sophisticated and/or fragile equipments. - Finally, the progressive development and/or acquisition of interactives laboratories (on CD-ROM or DVD) will further allow each student to work personnally, at his own rythm, on ensembles of sequences (visualisation of experimental results and of numerical simulation results, also animations). These cover phenomenological aspects as well as quantitative questions : visualisation, comprehension, analysis, answers to questions. References : - 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", John Wiley, Inc., 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 publ., NY, 1957. J. Happel and H. Brenner, "Low Reynolds number hydrodynamics", Noordhoff int. publ., Leyden, 1973. D.J. Tritton, "Physical fluid dynamics", Van Nostrand Reinhold, UK, 1985. R. Siegel and J. Howell, "Thermal radiation heat transfer", 2nd ed., McGraw-Hill, NY, 1981.
Cycle and year of study :	> Master [120] in Electro-mechanical Engineering > Master [120] in Mechanical Engineering
Faculty or entity in charge:	MECA