UCLouvain

# lmeca2648

*2023*

# Nuclear thermal-hydraulics (Centre d'étude nucléaire-Mol)

| 5.00 credits | 40.0 h + 7.5 h | Q1 |
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| Teacher(s) | Bartosiewicz Yann ; |
| Language : | English<br>> French-friendly |
| Place of the course | Louvain-la-Neuve |
| Main themes | • Reactor heat generation<br>• Transport equations (single-phase & two-phase flow)<br>• Thermal analysis of fuel elements<br>• (Single-phase fluid mechanics and heat transfer)'usually already known<br>• Two-phase flow dynamics<br>• Two-phase heat transfer<br>• Single heated channel; steady state analysis<br>• Single heated channel; transient analysis<br>• Flow loops<br>• Utilisation of established codes and introduction to advanced topics (modelling and thermalhydraulics for GEN4 reactors) |
| Learning outcomes | **At the end of this learning unit, the student is able to :**<br>1<br>• To be familiarised with various reactor types and their main design and operational characteristics<br>• To learn how to estimate the volumetric heat generation rate in fission reactor cores under normal operation and shutdown conditions<br>• To learn how to analyse the thermal performance of nuclear fuel elements<br>• To learn the basic fluid mechanics of single phase reactor cooling systems<br>• To learn to calculate pressure drop in reactor systems, including tube bundles, and spacer grids<br>• To learn to analyse the heat transfer characteristics of single phase reactor cooling systems<br>• To learn the basic fluid mechanics of two-phase systems, including flow regime maps, void-quality relations, pressure drop, and critical flow<br>• To learn the fundamentals of boiling heat transfer, and its implications for reactor design<br>• To learn the fundamentals of core thermal design, with attention to design uncertainty analysis and hot channel factors. |
| Evaluation methods | The evaluation is a combination of continuous and in-session exam.<br>The continuous part is a project (team of 2) where the students have to set up a simulation tools to calculate the pressure drop (plus temperature, quality profiles) in a boiling channel under different conditions. The exam is written (in english), and assess both theoretical and practical leaning outcomes. Thus this exam is split according a theoretical part (closed book) and a practical part (opened book)<br>The final mark is calculated as:<br>• Project + pratical part of the exam (11/20)<br>• Exam (9/20) |
| Teaching methods | • 30h of ex catedra lectures<br>• 30h of partially-supervised personnal work (project)<br>• 16h of supervised exercice sessions (exercice sessions)<br>The course takes place at the Nuclear Research Centre of Belgium (SCK.CEN) in gthe framework of the BNEN interuniversity programme (see: http://bnen.sckcen.be).<br>Courses taking place at SCK.CEN are condensed over a period of 2 intensive weeks of courses. |
| Content | • Lect. 1: Thermal design principles<br>• Lect. 2: Reactor energy distribution<br>• Lect. 3: Transport eqns. For 1-phase flow: Reminders/summary<br>• Lect. 4: Tranport eqns. For 2-phase flows:basic formulation<br>• Lect. 5: Tranport eqns. For 2-phase flows:equations<br>• Lect. 6: Thermodynamics, cycles: non-flow and steady flow<br>• Lect. 7: Thermodynamics, cycles: non steady flow first law<br>• Lect. 8: Thermal analysis of fuel elements<br>• Lect. 9: 1-phase fluid mechanics/heat transfer: Reminders/summary<br>• Lect. 10: 2-phase fluid mechanics/pressure drops<br>• Lect. 11: 2-phase fluid mechanics/pressure drops<br>• Lect. 12: 2-phase heat transfer (pool boiling) |

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| | • Lect. 13: 2-phase heat transfer (flow boiling)<br>• Lect. 14: Single-heated channel: steady state analysis |
| Inline resources | http://bnen.sckcen.be |
| Bibliography | • Todreas, N.E. and Kazimi, M.S. Nuclear System I: Thermal Hydraulic Fundamentals, CRC Press, 2012.<br>• Todreas, N. E. and Kazimi, M.S. Nuclear Systems II: Elements of Thermal Hydraulic Design, Hemisphere Publishing Corp., New York, 1990.<br><br>**REFERENCE BOOKS ON THE CONTENT**<br><br>• Todreas, N.E. and Kazimi, M.S. Nuclear System I: Thermal Hydraulic Fundamentals, CRC Press, 2012. Mandatory.<br>• Todreas, N. E. and Kazimi, M.S. Nuclear Systems II: Elements of Thermal Hydraulic Design, Hemisphere Publishing Corp., New York, 1990. Advised. |
| Other infos | **Note on the use of generative artificial intelligence:**<br><br>• The use of generative AI is tolerated, but its use must be thoughtful, critical and ethical.<br>• The student is required to systematically indicate all parts in which AIs have been used, e.g. in footnotes, specifying whether the AI was used to search for information, to write or correct the text, or to generate computer code. Sources of information must be systematically cited in accordance with bibliographic referencing standards. Students remain responsible for the content of their work, regardless of the sources used. |
| Faculty or entity in charge | MECA |

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