UNIVERSITÀ DI PISA

SINGLE AND TWO-PHASE THERMAL-HYDRAULICS

WALTER AMBROSINI

Anno accademico	2022/23
CdS	NUCLEAR ENGINEERING
Codice	669II
CFU	6

Moduli	Settore/i	Tipo	Ore	Docente/i
SINGLE AND TWO-PHASE THERMAL-HYDRAULICS	ING-IND/19	LEZIONI	60	WALTER AMBROSINI

Learning outcomes

Knowledge
The student who successfully completes the course will have the ability to quantitatively evaluate the main thermal-hydraulic phenomena relevant for light water nuclear reactor design and safety analysis; he/she will be able to demonstrate a solid knowledge of the phenomenological aspects needed for the thermal-hydraulics analysis of light water nuclear reactors ; he/she will be aware of the models adopted in major system and CFD codes for Thermal-hydraulic analysis.

Assessment criteria of knowledge
-The student will be assessed on his/her demonstrated ability to discuss the main course contents using the appropriate terminology. - During the oral exam the student must be able to demonstrate his/her knowledge of the course material and be able to discuss the reading matter thoughtfully and with propriety of expression. - The student's ability to explain correctly the main topics presented during the course at the board will be assessed. - The student must demonstrate the ability to put into practice and to execute, with critical awareness, the activities illustrated or carried out under the guidance of the teacher during the course.
Methods:

- Final oral exam
- Final written exam

Further information:
Detailed guidelines for the course and the teaching material are provided at the website: http://www.dimnp.unipi.it/walter-ambrosini/teamat.htm

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Skills
The student who successfully completes the course will have the ability to quantitatively evaluate the main thermal-hydraulic phenomena relevant for light water nuclear reactor design and safety analysis; he/she will be able to demonstrate a solid knowledge of the phenomenological aspects needed for the thermal-hydraulics analysis of light water nuclear reactors ; he/she will be aware of the models adopted in major system and CFD codes for Thermal-hydraulic analysis.

Assessment criteria of skills
-The student will be assessed on his/her demonstrated ability to discuss the main course contents using the appropriate terminology. - During the oral exam the student must be able to demonstrate his/her knowledge of the course material and be able to discuss the reading matter thoughtfully and with propriety of expression. - The student's ability to explain correctly the main topics presented during the course at the board will be assessed. - The student must demonstrate the ability to put into practice and to execute, with critical awareness, the activities illustrated or carried out under the guidance of the teacher during the course.

Behaviors
The student will be gradually introduced to critically consider the thermal-hydraulic aspects affecting safety of nuclear reactors. The nuclear safety culture will be the leading attitude to be developed while learning the quantitative evaluation of thermal and fluid-dynamic phenomena.

Assessment criteria of behaviors
Oral Examination including discussion of the safety relevance of the studied aspects.

Prerequisites
Basic knowledge and skills of Mathematics and Physics at BSc level. Basic knowledge and skills in thermodynamics and BSc level.

Teaching methods
Delivery: face to face
Learning activities:

- attending lectures
- participation in seminar
- Practical

Attendance: Advised
Teaching methods:

- Lectures
- Seminar
- Task-based learning/problem-based learning/inquiry-based learning

Syllabus
The Course is subdivided into 8 Teaching Units which are presented with the aid of notes in Word Format to be given to the students before the lectures and projected during teaching. Unit 1 – Fluids and Balance Equations; Unit 2 – Laminar Flow, Navier-Stokes Equations and Boundary Layer Phenomena; Unit 3 – Heat Transfer in Laminar Flow; Unit 4 – Momentum and Heat Transfer in Turbulent Flow; Unit 5a – Natural Circulation in Single-Phase Flow; Unit 5b – Notes on Compressible Single-Phase Flow Unit 5c – More on Turbulence, Unit 6 – Two-Phase Flow: General Definitions, Flow Regime Maps and Balance Equations, Unit 7 – Pressure Drops and Heat Transfer in Two-Phase Flow, Unit 8 – Some Specific Phenomena in Two-Phase Flow: Critical Flow, Flooding and Boiling Channel Instabilities
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Bibliography
The main suggested Textbook is: N.E. Todreas, M. S. Kazimi “Nuclear Systems I”, Taylor & Francis, 1990 or following Editions. Additional suggested readings will be proposed by the Teacher during the lectures.
Among them the following textbooks are quoted. For general treatments of single-phase fluid mechanic aspects
• D.J. Tritton “Physical Fluid Dynamics”, Oxford Science Publications, 2nd Edition, 1997.
• R.L. Mott “Applied Fluid Mechanics”, Prentice Hall, 5th Edition, 2000.
• B.R. Munson, D.F. Young, T.H. Okiishi “Fundamentals of Fluid Mechanics”, 4th Edition, Wiley, 2002, (with included CD-ROM).
• W. F. Hughes and J. A. Brighton “Fluid Dynamics”, McGraw Hill, Schaum’s Outlines, 3rd Edition, 1999. For specific single-phase heat transfer aspects
• F.P. Incropera and D.P. DeWitt “Fundamentals of Heat and Mass Transfer”, 4th Edition, 1996.
• Frank Kreith, Mark S. Bohn “Principles of Heat Transfer”, Thomson-Engineering, 2000. For summaries on turbulence modelling
• D.C. Wilcox “Turbulence Modeling for CFD”, 2nd Edition, DCW Industries, 1998.
• H.K. Veersteg and W. Malalasekera “An introduction to computational fluid dynamics”, Pearson, Prentice Hall, 1995. For two-phase flow and heat transfer
• J. G. Collier and J.R. Thome “Convective Boiling and Condensation”, Oxford Science Publications, 3rd Edition, Clarendon Press, Oxford, 1999.
• R.T. Lahey, Jr., F.J. Moody “The Thermal-Hydraulics of Boiling Water Nuclear Reactor”, American Nuclear Society, 2nd Edition, 1993.
• L.S. Tong, J. Weisman “Thermal Analysis of Pressurized Water Reactors”, American Nuclear Society, 3rd Edition, 1996. For a better understanding basing on audiovisual tools
• M. Van Dyke, “An Album of Fluid Motion”, The Parabolic Press, Stanford, CA, 1998.
• CD-ROM attached to the text B.R. Munson, D.F. Young, T.H. Okiishi “Fundamentals of Fluid Mechanics”, 4th Edition, Wiley, 2002,
• Multimedia Fluid Mechanics, CD-ROM of Cambridge University Press.

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Non-attending students info

The students will find the teaching material material on tha webpage of the teacher reported below.

Assessment methods

Oral Examination.

Additional web pages

- http://younuclear.ing.unipi.it/
- https://www.facebook.com/NuclearEngineeringPisa/
- https://www.linkedin.com/groups/4501364
- https://www.linkedin.com/groups/8463083

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