Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

Syllabus
Course description

Course title	Applications of Fluid Mechanics to Energy Engineering
Course code	45538
Scientific sector	ICAR/01 "Hydraulics"
Degree	Master Energy Engineering
Semester	2
Year	*OPT*
Academic year	2021/2022
Credits	6
Modular	no

Total lecturing hours	36
Total lab and exercise hours	24
Attendance	Not mandatory but strongly recommended
Recommended preliminary knowledge	Basic knowledge of fluid mechanics
Connections with other courses	The course provides in-depth knowledge of topics introduced only marginally in basic courses dealing with fluid mechanics and introduces advanced theoretical and modeling tools useful for other courses where fluids plays a key role within the teaching offer of the Master program, e.g. *Experimental methods in Thermo-fluid Dynamics*, *Environmental Fluid Mechanics / Hydropower Plants*, *Hydropower and wind power Systems*, *Fluid Machines Engineering*, *District heating systems design*.
Course page	

Specific educational objectives	Applications of Fluid Mechanics to Energy Engineering is an optional course within the master in Energy Engineering and is aimed to the students showing particular interest in fluid mechanics. Some specific topics addressed only marginally in the basic courses of hydraulics and fluid mechanics will be addressed, in order to provide the students with the fundamental knowledge about turbulent flows, physical modelling and CFD (Computational Fluid Dynamics). Within the tutorials and the homework the students will have the opportunity to compare some commercial codes applied to practical applications relevant to energy engineering.

Lecturer	Prof. Maurizio Righetti, Dr. Giuseppe Roberto Pisaturo, Prof. Michele Larcher, Dr. Andrea Menapace

Scientific sector of the lecturer	ICAR/02 and ICAR/01 (08/A1)
Teaching language	English
Office hours	Whole week, on appointment
Teaching assistant *(if any)*	-
Office hours	-
List of topics covered	The course will cover the following topics: • Fundamentals of fluid turbulence: - Interest of turbulent flows - Turbulent viscosity - Boundary layer - Free turbulence - Vortex dynamics - Homogeneous and isotropic turbulence - Direct and Large Eddy Simulation - Statistical models of turbulence - Overview of the major experimental techniques • Computational fluid dynamics (CFD): - Numerical simulation versus scale model test - 1D, 2D and 3D models, with focus on 3D - Detached Eddy Simulation (DES), Large Eddy Simulation (LES) and Reynolds-Averaged Navier-Stokes (RANS), including Reynolds stress - Role of boundary conditions, mesh and time step - Quality standards - Introduction into ANSYS - Application of ANSYS to energy engineering problems
Professional applications of the covered topics	The course provides in depth-knowledge on the use of Computational Fluid Dynamics (CFD) through theoretical and practical activities. CFD is becoming an increasingly important and used tool for the design, management and control of systems dealing with the flow of fluids, both for civil-environmental (e.g. river restoration, extreme events management, waste management, etc.) and industrial applications (e.g. hydropower systems, food industry, artificial snow production, fire-fighting systems, etc.). Important professional applications of the covered topics will be present both in the public and in the private sectors and in the free profession.
Teaching format	Lectures and tutorials in class; homework on the numerical solution of a fluid mechanics application.

Learning outcomes	By the end of the course, students are supposed to be able to: *- Knowledge and understanding:* (1) show the equations and explain the main principles relevant to turbulence, CFD, similarity and lubrication; (2) develop an intuitive comprehension. *- Applying knowledge and understanding:* (3) give examples of real applications and practical

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<tr><td></td><td>problems to underline how the topics treated in the course are used within engineering activity.
- Making judgements:
(4) the ability to make autonomous judgements in the choice and comparison of the suitable tools and for the solution of problems involving the mechanics of fluids.
- Communication skills:
(5) communication skills to correctly and properly present the concepts acquired in the course and the results of the homework.
- Learning skills:
(6) Ability to autonomously extend the knowledge acquired during the study course by reading and understanding scientific and technical documentation.</td></tr>
<tr><td>Assessment</td><td>The examination of the course consists in a written and an oral exam. The written exam consists in two exercises about fluid statics and dynamics. The candidates are requested to apply the main principles and equations of fluid mechanics in order to solve technical problems and so show their ability in applying knowledge and understanding and making judgements. The oral examination includes questions to assess the knowledge and understanding of the course topics, the learning skills and the communication skills.

Formative assessment<table><tr><th>Form</th><th>Length / duration</th><th>ILOs assessed</th></tr><tr><td>In class exercises</td><td>24 x 60 minutes</td><td>2, 3, 4, 6</td></tr></table>Summative assessment<table><tr><th>Form</th><th>%</th><th>Length / duration</th><th>ILOs assessed</th></tr><tr><td>Homework presentation</td><td>60%</td><td>15 minutes</td><td>1, 3, 4, 5, 6</td></tr><tr><td>Oral exam</td><td>40%</td><td>10 minutes</td><td>1, 2, 3, 4, 5, 6</td></tr></table></td></tr>
<tr><td>Assessment language</td><td>English</td></tr>
<tr><td>Evaluation criteria and criteria for awarding marks</td><td>Students will be evaluated on the base of an oral exam on the theoretical contents of the course (40%) and of the presentation and discussion of the homework (60%). At the oral part, knowledge and understanding of the topic (60%), the communication skills (20%) and the ability to summarize (20%) are assessed. At the presentation and discussion of the homework, applying knowledge and understanding (30%), making judgments (25%), the communication skills (25%) and the learning skills (20%) will be assessed.</td></tr>
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Required readings	The topics will be sampled out of different books. Some material will be made available in the reserve collection.
Supplementary readings	C. Bailly & G. Comte-Bellot, Turbulence, Springer, 2015 H. Tennekes & J.L. Lumley, A First Course in Turbulence. MIT Press, Cambridge 1972 J.O. Hinze, Turbulence, McGraw-Hill International Book Company, New York, 1975 D. C. Wilcox, Turbulence modeling for CFD, DCW Industries, 2006 H. Oertel (ed.), Prandtl-Essentials of Fluid Mechanics, Applied Mathematical Sciences 158, Springer, 2010 Y.A. Çengel, & J.M. Cimbala, Fluid Mechanics – Fundamentals and Applications, 2006, McGraw-Hill J.C. Gibbings, Dimensional Analysis, Springer, 2011 B. Zohuri, Dimensional Analysis and Self Similarity Methods for engineers and Scientists, Springer, 2015 L.P. Yarin, The Pi-Theorem. Applications to Fluid Mechanics and Heat and Mass Transfer, Springer, 2012 A. Adami, I modelli fisici nell'idraulica, CLEUP, 1994 W.E. Langlois and M.O. Deville, Slow Viscous Flow, Springer, 2014