UNICUSANO
ROME

Code: ING-IND/06 **Credits: 9**
Matter: Turbomachine Fluid Dynamics
Main language of instruction: Italian
Other language of instruction: English

Teaching Staff

Head instructor
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Introduction
Turbomachine fluid-dynamics subject is designed to give to the students a proper knowledge of the different flow behaviour for compressible fluids in ducts with constant and variable section. More specifically, different flows in nozzles, wave propagation, shock wave, and flow with friction and heat exchange will be analysed. Finally, some basics about turbulent flows will be given.
During the study, students should prepare the e-tivities in order to develop additional competences with referring to fluid-dynamics problems solved through computational tools like Matlab/Octave and to write official documents with Office package or similar.

Objectives
1. *To show the derivation of energy conservation equation;*
2. *To show the derivation of momentum equation and of the Navier-Stokes equations;*
3. *To show the possible geometries of a duct characterized by isentropic flow;*
4. *To show the waves propagation dynamics and to discuss the formation of a shock-wave;*
5. *To show the flow with friction;*
6. *To show the flow with heat exchange;*
7. *To provide some basic concepts about turbulence.*

Competencies:
- Knowledge and understanding: At the end of the subject study, the student will have demonstrated knowledge of the basic fluid-dynamics topics, flow evolution of compressible fluids and turbulence principles, and will have acquired the ability to analyse them. Furthermore, the student will acquire the knowledge of

the different flow modalities in constant and variable section ducts particular attention to: isentropic flows, flow with shock wave, flow with friction and exchange. Finally, the student will acquire methods for the analysis of complex fluid dynamics systems that present the simultaneous presence of different flow modalities. Moreover, through the Etivity the student will acquire the ability to formulate problems of fluid-dynamics within the Octave software (or similar).

- Applying knowledge and understanding: The student will be able to use the knowledge of basic fluid-dynamics and the principles of gas-dynamics for the analysis of the flow in ducts with constant or variable section; it will also be able to implement simple calculation codes for solving fluid dynamics problems. The Etivity are requested for the application of theoretical knowledge to practical problems to be solved with the aid of calculation software (Octave or similar). The student will acquire the critical ability to interpret the results obtained during a numerical exercise both in terms of physical consistency and in terms of engineering feasibility of the identified solution.
- Making judgements: The student will be able to identify the most appropriate mathematical models to describe the proposed problems, in accordance with the theoretical treatment developed during the lessons.
- Communication skills: The student will develop a correct and understandable scientific language that allows to express in a clear and unambiguous way the technical knowledge acquired in the context of the problems proposed and analysed. At the end of each Etivity the student will have to draw up a technical report analysing the results obtained and critically discussing the conditions of applicability of the equations used.
- Learning skills: At the end of the course the student will have knowledge of the fundamental notions necessary for the analysis of complex fluid-dynamics systems. The acquired knowledge will allow him to continue his engineering studies with improved maturity and will provide him with the bases to be able to learn what will be offered in the next courses of the specialist degree in mechanical engineering. In conclusion, the student will develop the ability to apply the acquired knowledge for the resolution of unfamiliar problems that have as their object the analysis of the fluid-dynamics processes.

Syllabus

Subject 1. *Introduction to basic concepts*
Subject 2. *Energy conservation equation*
Subject 3. *Multi-dimensional flow analysis and Navier-Stokes equations*
Subject -. *Etivity 1*
Subject 4. *Mono-dimensional flows through nozzles*
Subject 5. *Waves propagation*

Subject 6. *Flow with normal shock waves*
Subject 7. *Flow with friction*
Subject 8. *Flow with heat exchange*
Subject 9. *Basics on turbulence*
Subject -. *Etivity 2*

Evaluation system and criteria

The exam consists of a written test aimed at ascertaining the abilities to analyze and re-elaborate the concepts acquired and a series of activities (Etivity) carried out during the course in virtual classes. The evaluation of the two Etivity ranges from 0 to 5 points, and it is carried out during the duration of the course. The profit exam is valued from 0 to 25 points. During the final grade evaluation, Etivity will be taken into account if and only if the mark of the written test is higher than 15/25.
The written test includes 3 exercises on the main topics covered in the course: 1 exercise on the fundamental equations of fluid dynamics with a score ranging from 0 to 7 points; 1 exercise on the discharge modalities on the ducts with a vote ranging from 0 to 11 points; 1 exercise / theoretical question on the whole program with a vote ranging from 0 to 7 points. Particular attention in the evaluation of the answers given is payed to the student's ability to reformulate the teaching material provided.
The expected learning outcomes regarding the knowledge of the topics and the ability to apply it are assessed by the written test, while the communication skills, the ability to draw conclusions and the capacity for self-learning are evaluated in itinere through the Etivity.

Bibliography and resources

Materials to consult:

Teaching materials provided by the teacher

Recommended bibliography:

Fundamentals of Compressible Flow, S.M. YAHYA, Wiley Eastern Limited