

Code: ING-IND/06

Credits: 9

Matter: Dynamics of Turbulent Flows

Main language of instruction: Italian

Other language of instruction: English

Teaching Staff

Head instructor

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Introduction

This teaching **Dynamics of Turbulent Flows** illustrates the current state of knowledge of turbulent phenomena. Turbulence, as well known, is very often present in fluid flows, and it makes complicated the resolution of engineering design problems or the evaluation of functional behavior in a multitude of technical applications. The complication descends from the not yet complete predictability of the mechanism of onset, development and effects of the turbulent phenomenon. Nevertheless the state of the art on the subject allows to face many problems with reliability of the proposals within the limits of their fields of applicability. At this aim the teaching provides a panorama on the current knowledge so that a critical assessment can be made of technical interventions in the engineering areas.

Objectives

The teaching has the following educational objectives:

1. Explanation of the concepts, illustration of the settings and analysis of the methodologies necessary to tackle the study of the turbulence, with reference to deformable bodies, vorticity and rotational movement of the fluid flows.
2. Explanation of the concepts and methodologies concerning hydrodynamic stability, as a prologue to the turbulence triggering.
3. Reveal the approach of studying the mechanics of turbulence and the consequent equations that describe its general synthesized behavior and some peculiar characteristics, as well as to describe the state of the art reached in the understanding of turbulent chaotic behavior.
4. Explanation of the concepts and methodologies developed so far in relation to the numerical simulation of turbulence, juxtaposing them with the methods of realization of physical models

Competencies:

Officially there are no preparatory courses for the study of the treated topics. However, it is necessary that the student who approaches the study of the arguments treated in this teaching has a good grasp of some topics of basic fluid mechanics, typically carried out in the basic courses of Hydraulics and/or Fluid Dynamics.

Therefore, students who believe they have some gaps on these subjects necessary to follow with profit this teaching are strongly invited to view the material of the Hydraulics and / or Fluid Dynamics courses and to practice these preliminary topics.

The students who follow this teaching are already graduate students and their knowledge of the concepts and basic topics of mathematical analysis and general physics is therefore taken for granted.

The expected learning outcomes are the following.

Knowledge and Understanding: The student at the successful conclusion of the teaching will have demonstrated the ability to illustrate the behavioral mechanism of the turbulent outflow. He will be able to describe the state of the current art on the subject and the evaluations on the procedure limits.

applying knowledge and understanding: The student will be able to describe the panorama of numerical calculation techniques, their analyzes and assessments currently developed in technical applications for the purpose of determining their limits and applicability fields. The acquisition of these topics allows the future engineer to face the engineering problems of turbulent flow with mastery of current skills and to develop new techniques for their resolution. At the successful conclusion of the course the student will also have shown that he is aware of the different application cases and the related solution techniques in which the current experience is sufficiently developed and consolidated to be able to face both the design and verification problems (for example uniform turbulent motion or turbulent boundary layer).

making judgements: At the end of the course the student will be able to describe and identify the critical points in the analysis and in the project synthesis involving turbulent phenomena.

communication skills: The student will have acquired a correct and understandable technical-scientific language that allows him to relate to the specific professional environment, being able to express his opinions clearly and unambiguously, as well as accepting the beliefs of others.

learning skills: The student will have acquired the ability to apply the acquired knowledge to develop or anyway understand the development of problem solving techniques involving turbulent phenomena.

Course Structure:

The teaching is organized in modules, each of which consists of prerecorded audio-video lectures and related lecture notes, which together constitute the study materials to support the exam available on the platform. Each lesson is about half an hour for a total of about 13 hours of video recordings. Then some complementary modules, that are extensions or introductory references to the contents of the course, are offered, also available on the platform. The lessons of the optional modules are in total 28 or 14 hours of video recordings. The topics of the optional modules are not part of the teaching examination program but support the student to recall notions, deepen or extend topics useful for understanding and learning the contents of teaching. There are also offered on the platform 4 self-assessment tests, of asynchronous type, supplied with the modules. The self-assessment tests allow students to ascertain both the understanding and the degree of knowledge acquired, of the subjects studied.

A "virtual class" forum is also proposed, organized in several 2-hour sessions in which the answers to 10 quiz tests are discussed.

The teaching foresees 9 CFU. The total study load is approximately 225 hours, divided as follows:

about 133 hours for the visualization and study of the videotaped material (13.3 hours of videotaped material);

about 42 hours for the only visualization of the videotaped material (14 hours of videotaped material);

about 30 hours for the discussion on the Forum;

about 20 hours for carrying out self-assessment tests and understanding the results.

It is advisable to distribute the study evenly over a 10-week period by dedicating approximately 22 hours of study per week to it.

Syllabus

Programme of the course:

Complementary Modulus 1 – DESCRIPTION OF THE MOTION OF DEFORMABLE
(Week: First; Student Work Hours 7.5)

Module 1 – ROTATIONAL FLOWS AND VORTICITY (Week: First; Student Work Hours 20)

Complementary Modulus 2 – IRROTATIONAL FLOWS (Week: Second; Student Work Hours 5)

Complementary Modulus 3 – VISCOUS FLOWS (Week: Second; Student Work Hours 15)

Module 2 – HYDRODYNAMIC STABILITY (Week: Third; Student Work Hours 20)

Module 3 – DYNAMICS OF TURBULENCE (Week: Fourth; Student Work Hours 20)

Module 4 – KINETIC ENERGY BALANCES (Week: Fifth; Student Work Hours 20)

Module 5 – UNIFORM TURBULENT FLOW (Week: Sixth; Student Work Hours 10; Test and Forum activities Hours 11)

Module 6 – TURBULENT BOUNDARY LAYER (Week: Seventh; Student Work Hours 10; Test and Forum activities Hours 11)

Module 7 – NUMERICAL MODELS OF TURBULENCE (Week: Eighth; Student Work Hours 15; Forum activities Hours 6)

Complementary Modulus 4 – ONE-DIMENSIONAL SCHEMES AND PHYSICAL MODELS (Week: Ninth; Student Work Hours 10.5; Test and Forum activities Hours 11)

Module 8 – DETERMINISTIC CHAOS (Week: Tenth; Student Work Hours 18; Forum activities Hours 6)

Evaluation system and criteria:

The exam consists of a written test lasting 90 minutes and in the evaluation of the activities carried out during the forum in the virtual classes.

During the written test it is not allowed to use handouts, notes, texts or forms in paper or digital format. Use of the calculator is permitted even if deemed unnecessary. The written test consists in the development of a topic with which the student must summarize, with a proper formulation and with a correct technical-scientific language, an argument of the program. Furthermore, on the same topic, the student is asked to answer a few quiz tests, usually five, with multiple answers of which only one is correct. The exact answers to the quiz allow the student to demonstrate the acquisition of the ability to apply the knowledge learned and in any case to detect the critical points.

The evaluation of the activities in the forum is carried out in progress during the forum itself. The result of the test evaluation is a score expressed in thirtieths. To this score some points, 5 maximum, can be added for the activities in the forum. The maximum score is “30 cum laude”.

Bibliography and resources

Materials to consult: The educational material, prepared by the teacher, is on the platform. It entirely covers the teaching program. This material is divided into 8 modules and 4 complementary modules. Each one contains lecture notes and video lessons.

Recommended bibliography: The bibliography useful for further information is mentioned in the lecture notes.