UNICUSANO
ROME

Code: ICAR/01 **Credits: 9**
Matter: Hydraulics
Main language of instruction: Italian
Other language of instruction: English

Teaching Staff

Head instructor
Eng. Silvia Di Francesco - silvia.difrancesco@unicusano.it

Introduction

1. *Objective of the course :*

The course deals with the basic aspects of hydraulics, providing essential tools for solving classical design problems in civil and environmental engineering. The course proposes the fundamental concepts of mathematical models able to describe the behavior of incompressible fluids, with particular reference to hydrostatics, kinematics and dynamics of ideal fluids (absence of viscous efforts) and real fluids.
Furthermore, the training objective of the course is to provide the student with a knowledge of the details of sizing and verification of pressure pipeline systems and of the modeling of free surface currents. The E-tivities associated with the course develop the skills necessary to formulate the problems of hydraulics.

Objectives

2. *Course Structure:*

The course is organized in 12 subjects: Fluids and their movement, Hydrostatics, Kinematics of fluids, Basic equations of fluid dynamics , Bernoulli's theorem and its applications, Equation of motion of real fluids (NS equations), Pipe flow, Practical problems related to long pipelines (design and verification), Free surface flows, Phoronomy, Water filtration processes, Measuring instruments.
The "virtual classroom" forum includes 3 Etivity which foresee the application of the knowledge, acquired in theory lessons, to the solution of problems typical of hydraulics.

Competencies:

The student will be able to use the knowledge of the hydrostatic, kinematic and fluid dynamics of simple hydraulic infrastructures for their analysis and dimensioning:

- evaluation of hydrostatic and dynamic forces

- design and verification of pipeline systems
- modeling of free surface currents

The Etivity provide tools for the application of theoretical knowledge to practical problems and allow students to acquire skills and competencies in calculation software: Excel, Epanet, HEC-RAS.

Moreover the student will be able:

- to identify the most appropriate models to describe and simulate the typical problems of a hydraulic system.
- to interpret the results obtained during a numerical exercise both in terms of physical consistency of the results obtained and in terms of engineering feasibility of the identified solution

Syllabus

3. *Programme of the course:*

Subject 1. The fluids and their movement

Definition of fluid, The fluids as continuous media Unit of measure Forces acting on a continuous (fluid), The stress tensor, Density, Specific weight, Compressibility, Surface tension, Viscosity, Vapour pressure, Thermal properties, Flow regimes

Subject 2 - Hydrostatics

Stresses in fluids at rest, Equation of the statics of fluids. Global equation of fluid statics. Statics of heavy incompressible fluids. The Hydrostatic Paradox. Absolute and Gage Pressures. Measurement of pressure. Hydrostatic Forces on Submerged Plane Surfaces. Elements of static of flat surfaces. Thrust on a curved surface. Fluids of low specific weight.

Etivity 1 - Hydrostatic: pressure variation in fluids at rest and calculation of thrusts on flat and curved surfaces.

Subject 3 - Fluid kinematics

Speed and acceleration: Eulerian and Lagrangian approach, Substantial Derivative, Characteristic elements of motion, The concept of flow, Types of movement, Continuity equation

Subject 4 Basic equations of fluid dynamics

Local equation of dynamic equilibrium, Global equation of dynamic (Impulse-momentum equation)

Subject 5 Bernoulli's theorem

Pressure distribution in the normal plane. Linear currents. Bernoulli's theorem. Geometric and energy interpretation - Applications - Extension to real fluids - Power of a current in a section. Extension of Bernoulli's theorem to a current

Module 6 Equation of motion of real fluids

State of stress: normal component and deviatoric, Constitutive equations, Navier-Stokes, Global equation of equilibrium (incompressible fluids), Dragging action of a current

Subject 7 Flow in pipes

Current pressure-General characteristics, Flow regimes and Reynolds number, Features of the turbulent motion, Viscous and turbulent shear stresses, Laminar flow, The continuous head loss, The Abaco Moody, Issues of design and analysis, Theoretical velocity profiles in turbulent flows Practical formulas for head losses, Local head (minor) losses, Hydraulic calculation of conduct

Subject 8 Practical problems on long pipes

Conduct with constant diameter and uniformly distributed discharges, Verification of pipeline systems, Conduct connecting 2 tanks, Three tanks connected, Pipelines in parallel, Cross Method , Sizing of pipeline systems, Pump Systems, Lifting, Possible altimetric issues

Etivity 2 - Verification of a water distribution network.

Subject 9 Free surface flows

Specific energy (the energy characteristics of a current),The equations of continuity and energy (perpetual motion 1D), Uniform motion, in weak and very steep Riverbeds , Kinematic characteristics of of currents, Froude number, free surface profile in steady flow, Hydraulic jump, Application Examples

Etivity 3 - Tracing of the permanent motion profiles with the help of openSource software (HEC-RAS).

Subject 10 Foronomy

Swing lights and weir lights

Module 11 Filtration motions

Schematic of filtration motions. Darcy's law. Artesian and phreatic groundwater wells

Evaluation system and criteria

The exam consists in a written test and a series of activities (E-tivity) carried out during the course in virtual classes.

E-tivity are evaluated from 0 to 5 points, while 0-25 points are assigned at the written test to be done at the Rome office or at the educational poles upon booking by the student.

The written test normally includes:

• 1-2 numerical exercises concerning hydrostatics and fluid dynamics, dimensioning and verification of short and long pipelines, analysis and design of free surface channels.

- 2-3 theoretical questions on the main topics covered in the course. Particular attention in the evaluation of the answers given is put on the student's ability to solve the numerical problem and to rework the material on the platform. 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 only permitted in the case of non-scientific or programmable calculators

Bibliography and resources

4. *Materials to consult:*

The educational material, provided by the teacher and available on the platform, is divided into 12 modules. They entirely cover the program; each of them contains lecture notes, slides and video lessons in which the teacher comments on the slides. This material contains all the elements necessary to deal with the study of the subject.

5. *Recommended bibliography:*

- Çengel Yunus A, John M. Cimbala, Fluid Mechanics: Fundamentals and Applications, III ed, McGraw-hill, 2013
- Chow, V.T. , Open-Channel Hydraulics, McGraw-Hill, 1959
- Citrini D., Noseda G., Idraulica, II ed., Milano, Casa Editrice Ambrosiana, 1987
- Mossa Michele, Antonio Felice Petrillo, Idraulica, Casa Editrice Ambrosiana, 2013