# Hydraulics

1. **Course number and name:** 020HYDES3 Hydraulics

2. **Credits and contact hours:** 4 ECTS credits, 2x1:15 contact hours per week

3. **Name(s) of instructor(s) or course coordinator(s):** Cynthia Andraos

4. **Instructional Materials:** PowerPoint slides; course handouts; lab experiments

   References:

   Class notes prepared by Sélim CATAFAGO

   Textbook: Introduction to fluid mechanics/PJ Prithard, Hoboken, New Jersey, Fox, McDonald's P. P. (2011).

5. **Specific course information**
   a. **Catalog description:**
   This course focuses on steady-state and transient flows. Based on an in-depth approach to pressure losses, special attention is paid to the design of simple and complex networks. The safety of networks is approached by the study of transient regimes and the sizing of adequate protections. Extended network analysis is undertaken by studying pumps and turbines.

   b. **Prerequisite:** Fluid Mechanics (020MEFES1) or Fluid Mechanics 1 (020MF1ES1).

   c. **Required** for ME students, **Selected Elective** for EE students.

6. **Educational objectives for the course**
   a. **Specific outcomes of instruction:**
   By the end of the course, the students will be able to:
   - Understand the mechanisms that govern water distribution networks.
   - Undertake the study of water supply and distribution projects considering technical aspects.

   b. **PI addressed by the course:**

| PI | 1.1 | 1.2 | 1.3 | 2.4 | 6.1 | 6.2 | 6.3 | 6.4 |
|---|---|---|---|---|---|---|---|---|
| Covered | x | x | x | x | x | x | x | x |
| Assessed | x | x | x | x | | | | |

7. **Brief list of topics to be covered**

**Part I: Steady-State and Pressurized Networks**

1. **Laminar and Turbulent Pressurized Flow**

Empirical formulas, pressure loss in cylindrical pipes under laminar flow conditions,

pressure losses in the case of smooth turbulent flows, rough turbulence and cases of industrial flows.

2. **Headloss Calculations and Steady-State Networks' Basics**
   Headlosses in pipe fittings, contractions/expansions and bends, Hydraulic networks in steady-state, Problem variables, Laws of nodes and branches, System of equations of a network.
3. **Methods of Solution**
   Simple networks, Hydraulic method of characteristics, Analytical resolution, Complex networks, Matrix iterative resolution, Hardy-Cross method, Newton Raphson method, Linear method, En-route service, Neutral point position, Piezometric line.

**Part II: Unsteady Network Conditions**

1. **Generalities**
   Unsteady flow in pressurized pipes, General equations, Hyperbolic partial differential equations, Simplified resolution, Method of characteristics
   Interpretation of the method of the characteristics results, Wave behavior during changes in geometrical and physical characteristics of pipes
   Graphical solutions with and without headloss, Numerical resolutions
2. **Protection of Pressurized Networks**
   Simplified air reservoir design, Finite difference method, Bypass valves, Water hammer protection valves, Balance chimney.

**Part IV: Turbomachines**

General information on turbomachinery, Characteristic curves of centrifugal pumps, Theoretical and real characteristics, Coupling of pumps
Determination of operating conditions on a hydraulic network, Stability of operation, Power and efficiency properties, Similarity laws between identical pumps, Pump selection
Pump location, Cavitation and concept of NPSH, Pump starting problems, Problems in pumping conditions variations, Selection of characteristic curve, Some technological elements
Turbines, turbines scaling laws.

**Laboratory Experiments**

Pumps, headlosses in pressurized pipes.