Hydraulics

1. **Course number and name:** 020HYDGS3 Hydraulics

2. **Credits and contact hours:** 6 ECTS credits, 3x1.25 hours

3. **Name(s) of instructor(s) or course coordinator(s):** Renalda EL-SAMRA

4. **Instructional Materials:**
   a. Class notes prepared by Sélim CATAFAGO

   b. Text book: 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. In addition to technical aspects, economic aspects are considered through different optimization methods. 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. Free-surface flows complement the various flow aspects an engineer may encounter in practice.

   b. **Prerequisites or co-requisites:** 020MEFGS2 Fluid Mechanics

   c. **Required:** Required for all Civil Engineering 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 taking into account the technical and economic aspects

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

PI	1.1	1.4	2.3
Covered	yes	yes	yes
Assessed			

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: Network Economic Study and Optimization

Economic optimization principles, Evaluation of project profitability, Analysis of optimal solutions, Network optimization,
Optimization of a discharge pipe, Optimization of reservoir elevation. Network performance, System reliability analysis.

Part III: 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

Part V: Free Surface Flow

Different types of flows, Uniform flows, Flow rate calculations, Normal depth, Critical depth, Gradually varied flows, Water surface profiles
Differential equation of the surface profile curve, Methods of resolution. Hydraulic jump, Fundamental relationships in horizontal channel, Headloss in jump, Jump length height and position, Jump displacement, Jump usage

Laboratory Experiments

Pumps, headlosses in pressurized pipes, infiltration, open channel flow