

CIVIL-312: Hydraulic Engineering and Infrastructures

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Final in-depth evaluation are now available via Moodle:

- Log onto Moodle and stay on the dashboard (not the course page).
- Click on the arrow to the top right of the screen which will reveal a block that contains the entitled “In-depth evaluation” tile.
- Select the course and complete the feedback.

If you wish, let's take **5 minutes now** to fill it out.

Otherwise, you can complete it **any time before January 11**.

Thank You!



Quick Recap, Exam structure & Study Guide

- 4 modules covered:

**A: REVIEW OF
FUNDAMENTALS**



**B: PRESSURIZED PIPE
FLOWS**



**C: OPEN CHANNEL
HYDRAULICS**



**D: DAMS, RELEVANT
STRUCTURES**



Week 1 & 2

■ System vs Control Volume

- System: fixed mass of fluid (Lagrangian view)
- Control volume: fixed region in space (Eulerian view)

■ Reynolds Transport Theorem (RTT)

- Derivation and significance: bridge between system laws and control volume analysis
- Leads to the **three fundamental equations**:
 - Conservation of Mass — the Continuity Equation: $Q_{in} = Q_{out}$
 - Energy Equation: $\frac{P_1}{\gamma} + \frac{v_1^2}{2g} + z_1 + energy_{loss} = \frac{P_2}{\gamma} + \frac{v_2^2}{2g} + z_2 + energy_{gain}$
 - Momentum Equation: in 1D $\rightarrow \Sigma \vec{F}_{ext} = \rho Q (\vec{v}_2 - \vec{v}_1)$

■ Hydrostatics: fluid at rest

- No velocity \rightarrow no shear
- Forces are only normal to the surface
- Pascal Law: pressure at a point in a fluid at rest is independent of the direction (as long as there are no sheering stresses)

■ Hydrostatic Law

- $\frac{dp}{dz} = -\gamma \Rightarrow$ piezometric head: $\left(\frac{p}{\gamma} + z\right) = \text{constant}$
- Pressure varies only with depth
- Exercise

■ Hydrostatic forces

- Forces on a plane surface: magnitude and application point
- Pressure prism
- Forces on a curves surface
- Exercises

Weeks 3-5

- **Definition of Pressurized Pipe Flows**
 - Pipe completely full, **no free surface**
 - Flow driven mainly by **pressure differences**
- **Flow regimes**
 - Definition of **Reynolds number**: inertia vs viscosity
 - Laminar, transitional, turbulent flow
 - Flow regime controls **velocity profile, stresses, and losses**
- **Energy balance in pipes**
 - Derivation of the equation
 - Total head = pressure + elevation + velocity
 - **Head losses** represent energy dissipation
 - Pumps add energy, turbines remove energy
 - Visualization using **EGL** and **HGL**

- **Head losses**
 - **Major losses:** pipe wall friction (Darcy–Weisbach). Definition and derivation
 - **Minor losses:** bends, valves, fittings
 - Losses typically expressed as function of $V^2/2g$
- **Pumps and systems**
 - Pump performance curve vs system curve
 - **Operating point** = intersection
 - **Series** → increase head
 - **Parallel** → increase discharge
 - Cavitation and Net Positive Suction Head
- **Pipe networks**
 - Governed by:
 - **Continuity at nodes**
 - **Energy conservation in pipes/loops**
 - Solved by:
 - Hardy Cross (conceptual, hand calculations)
 - Newton-Raphson → Numerical solvers: EPANET (not evaluated during exam)

Weeks 6-9

- **Definition of Open Channel Flows**
 - Open-channel flows are **primarily gravity-driven**
 - **Free surface** and why it adds complexity
 - Flow classification and physical implications:
 - Steady vs Unsteady
 - Uniform vs Non-uniform
 - Gradually Varied Flow vs Rapidly Varied Flow
 - Subcritical, critical, and supercritical flow
- **Energy and Momentum in Open Channels**
 - Correctly write and interpret the **energy equation** for open-channel flow
 - Understand the meaning of:
 - Channel slope S_0
 - Friction slope S_f
 - Explain why, in **uniform flow**, $S_0 = S_f$

■ Uniform Flow and resistance

- From momentum balance and resistance considerations we introduced Chézy and Manning equation
- Derive **normal depth** and understand its physical meaning
- Understand the physical meaning and Explain the role of the hydraulic radius, channel roughness (Manning n), channel slope
- Flowrate in compound channels

■ Specific Energy and Critical Flow

- Define **specific energy**
- Interpret the **specific energy–depth curve**
- Explain alternate depths & minimum specific energy
- Define and interpret the **Froude number**
- Explain the physical meaning of:
 - Subcritical flow ($Fr < 1$)
 - Supercritical flow ($Fr > 1$)
 - Critical flow ($Fr = 1$)
- Compute and interpret **critical depth** (especially for rectangular channels)

■ Gradually Varied Flow (GVF)

- Understand the **GVF equation** and its physical meaning
- Explain the role of:
 - Bed slope
 - Friction
 - Froude number
- Classify and recognize **water surface profiles**
- Identify **control points** and explain how they influence the flow
- Know the **direction of computation** (upstream or downstream) depending on the local flow regime
- Draw qualitatively water profiles

- **Rapidly Varied Flow – Hydraulic Jump**
 - Explain what a **hydraulic jump** is and when it occurs
 - Recognize the transition from **supercritical to subcritical flow**
 - Understand the physical meaning of the location of the HJ: continuity and momentum balance
 - Define and compute **conjugate (sequent) depths**
 - Energy dissipation in a hydraulic jump
- **Numerical solver: Direct Step Method & HEC-RAS** (not evaluated during exam)

Weeks 10 - 14

■ Weirs and Gates

- How they affect water level and discharge
- Derive and Interpret discharge equations and the role of discharge coefficients
- Recognize the role of contractions and submergence
- Drown vs Free Hydraulic Jumps
- Exercises

■ Dams & Spillways

- Definition & classification – purpose, dimension, type
- Spillway design – discharge and shape
- Under design and cavitation

- **Stilling Basins & Energy Dissipators**
 - Function and types
 - Design considerations and process
- **Channel Design & Culvert**
 - Types and purposes
 - Design consideration
 - Culvert Hydraulics and design process
 - Inlet control vs Outlet control
 - Inlet Q-H relations

- **A Mock-Exam will be posted soon.** You can use it as study material and feel free to ask questions.
- I will send an email with precise instructions ahead of the exam.

Final Exam (60% of the grade)

When: **Wednesday 21.01.2026** from **09h15** to **12h15**

Where: **CE 1-1, CE 1-3**

- **Covers the entire course material**
- **Part I:** Theory and conceptual questions
 - 45 min
 - Closed books / no cheat sheet
- **Part II:** Written exercises – same style as those seen in class (and in the book)
 - 2 hours
 - 2 pages cheat sheet (only formulas allowed on it; no solved problems)
 - Classic scientific calculator (programmable calculator **are not allowed**)