Swiss Federal Institute of Technology Lausanne

School of Architecture, Civil and Environmental Engineering

Computational Methods in Hydrodynamics (CIVL 471)

Instructor:

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Visiting Professor, Platforme de Constructions de Hydraulique, EPFL

Fall 2024

Course Outline

Instructor:

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Zoom link for Office hours: https://yorku.zoom.us/my/shookakarimpour

Room and Time:

Course delivery will be online: including a total of 2.0 hours/week of lectures. 2 extra hours are dedicated to problem solving and assignments.

Lectures: Lectures Mondays 2:00 - 3:45 am; Problem solving: 4:00 - 5:30 pm

Office hours Monday 11:00 am - noon (in-person / or online)

Topics and Content:

Introduction and Governing Equations

- Momentum and Mass Conservation
- Shallow Water Equations
- Nature of Partial Differential Equations

Numerical Methods used in Hydrodynamics

- General Principles and Steps
- Finite Difference Methods and Errors
- Finite Volume Methods
- Pressure and Velocity Coupling
- Stability and Convergence conditions

Advection and Diffusion Fluxes

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- Flux Order of Estimation - FOU, CD and QUICK schemes
- False Diffusion and Spurious Oscillations

- Flux Limiters

Unsteady Flow and Time Marching

- Explicit Scheme
- Semi-Explicit Scheme
- Implicit Scheme

Turbulent Transport Processes

- Turbulent diffusion
- Length scale and velocity scale of turbulent motion
- Turbulence modelling

Bouyancy, Friction, and other Sources

- Stable and unstable stratification
- Bed-friction effect
- Effects of rotation and streamline curvature

...... & OTHERS (e.g., pressure/velocity coupling schemes, turbulent dispersion models, ...)

List of Recommended References:

Important: Course notes and program templates will be provided on course MOODLE. These are recommended but not required.

- An introduction to Computational fluid dynamics, H.K. Versteeg and W. Malalasekera
- Computational Hydraulics: Numerical Methods and modelling, by Popescu (Author), Ioana Popescu (Author), IWA Publishing;
- Computational Modelling in Hydraulic and Coastal Engineering, Christopher G. Koutitas and Panagiotis D. Scarlatos, Taylor and Francis;

Assessment and Evaluation:

- Assignments, including Python program & full report
  Weekly/biweekly 6 Assignments 50%
  Python templates for assignments will be provided.
- Completing 3 *Challenges* or 1 *Research Paper*
  Throughout the semester 5-6 challenges will be given. Students will have to participate in 3 challenges 10%
- Final Project, including interim & final presentations and report
  Late November to mid December 40%

Policy and Notes for Assessment and Evaluation:

- Participation is required in live and recorded lectures are required.
- All communications will be via e-class. Stay tune for announcements and files on e-class.
- Assignments received later than the due date will be penalized (25% deduction per day that assignment is late).
- One ONE-DAY grace period throughout the semester applies to all students.

Course Learning Outcomes:

- The student will demonstrate an ability to recognize the type of fluid flow that is occurring in a particular physical system and to use the appropriate model equations to investigate the flow.
- The course material will improve the student's understanding of the basic principles of open channel hydrodynamics.
- Students will be able to develop advanced numerical algorithms to form efficient and convergent solutions to hydrodynamic challenges.
- Through the completion of this course and related assignments and tasks, student's research and communication skills will improve, as he/she conducts self-directed, detailed study of complex fluid-flow problems and communicate the results in written and verbal forms.