

457.560 Advanced Environmental Hydraulics I: River Mixing Theory

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Objectives:

This course deals with the fluid mechanics to problems of pollutant transport and mixing and in the water environments. This course is suitable to graduate students of Earth Science and Civil & Environmental Engineering majors in any level as well as practicing hydraulic and environmental engineers for their practices. The students will obtain a deep understanding of basic theories as well as the future technology in the environmental hydraulic engineering.

Description:

This course deals with the analysis and prediction of the mixing and transport phenomena of various pollutants introduced into river environments. In the first part of this course, fundamental theory and analytical methods for the diffusion and dispersion of the substance are discussed in greater detail. In the latter part, practical problems and field studies in real streams and estuaries are covered. Numerical modeling techniques of hydrodynamics and solute transport in rivers and estuaries are also treated.

Contents:

1. Introduction to Environmental Hydraulics
2. Advection-Diffusion Equations
3. Turbulent Diffusion
4. Shear Flow Dispersion
5. Mixing in Rivers
6. River Water Quality Modeling
7. Field Studies of Mixing in Rivers
8. Mixing in Estuaries
9. Numerical Models for River Mixing

Text:

1. Fischer, H.B. et al., 1979, Mixing in Inland and Coastal Waters, Academic Press, New York, N.Y.

Reference:

1. Crank, J., 1975, The Mathematics of Diffusion, 2nd Ed., Oxford Science.
2. Fischer, H.B. ed., 1979, Transport Models for Inland and Coastal Waters, Academic Press, New York, N.Y.
3. Thomann, R.V. and Mueller, J.A., 1987, Principles of Surface Water Quality Modeling & Control, Harper & Row.
4. Rutherford, J.C., 1994, River Mixing, John Wiley & Sons.
5. Shen, H.H. ed., 2002, Environmental Fluid Mechanics – Theories and Applications, ASCE.
6. Chanson, H., 2004, Environmental Hydraulics of Open Channel Flows, Elsevier.

Prerequisites:

Elementary Fluid Mechanics and Lab.
Hydraulics and Lab.

Grade:

| | |
|----------------------|-----|
| Homework Assignments | 30% |
| Term Project | 30% |
| Final Exam. | 40% |

Lecture Calendar:

| Week | Contents | Assignments/Exam. |
|----------------|--|--|
| Week 1 | Introduction to Environmental Hydraulics | |
| Week 2 | Advection-Diffusion Equation (I) | HW #1 (Outfall-water intake) |
| Week 3 | Advection-Diffusion Equation (II) | HW #2 (Diffusion coefficient and peak concentration) |
| Week 4 | Advection-Diffusion Equation (III) | |
| Week 5 | Turbulent Diffusion | HW #3 (Analytical solution) |
| Week 6 | Shear Flow Dispersion (I) | Term project proposal presentation |
| Week 7 | Shear Flow Dispersion (II) | HW #4 (Dispersion within lanes) |
| Week 8 | Mixing in Rivers (I) | HW #5 (Longitudinal dispersion) |
| Week 9 | Mixing in Rivers (II) | HW #6 (Moment method and routing procedure) |
| Week 10 | River Water Quality Modeling | HW #7 (DO concentration profile) |
| Week 11 | Field Studies of Mixing in Rivers (I) | HW #8 (Analytical solution) |
| Week 12 | Field Studies of Mixing in Rivers (II) | |
| Week 13 | Mixing in Estuaries | |
| Week 14 | Numerical Models for River Mixing | |
| Week 15 | Term project final report presentation | Final Exam. |

Term Project

A. Outline

| | Proposal | Report |
|-------------------|-------------|---------------|
| Presentation | Week 6 | Week 15 |
| Presentation Time | 5 min | 15 min |
| Materials | PPT 6 pgs. | PPT 15 pgs. |
| Submission | Week 6 | Week 15 |
| Length of Report | A4 2-4 pgs. | A4 10-20 pgs. |

* Term Project title (English) should be submitted at week 4.

B. Proposal and Report Outline

1. Proposal

- (1) Research title
- (2) Necessity and background of research
- (3) Objective and scope of research
- (4) Research methodology
- (5) Reference

2. Report (Recommended)

- (1) Title
- (2) Abstract (including keywords)
- (3) Introduction – Necessity and objective of research
- (4) Body- Research trends, theoretical studies, experiment/numerical simulations
- (5) Summary and conclusion
- (6) Reference

* Remarks: Spacing between lines should be 1-1/2 space, unimportant pictures and graphs should be included in the appendix.

C. Presentation Method (Recommended)

- (1) Introduce the thesis title and author
- (2) Issue and necessity of research
- (3) Previous and current research trends
- (4) Research detail and methodology
- (5) Summary and conclusion

* Remarks

- (1) Introduce only significant governing equation and BC& IC.
- (2) Introduce only significant pictures and graphs.
- (3) Proposal and Report must be written in English (Refer to hydraulic terminology dictionary).
- (4) Punctuality is important (Practice in advance).

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Suggested Term Project Topics

1. Commercial Software

Modeling pollutant transport in a meandering river using RAMS/SMS/iRIC

Modeling hydrodynamics of flow near the river structures using EFDC/iRIC

Modeling sediment transport in a river using CCHE-2D/iRIC

Modeling mixing characteristics of multiport diffuser using CORMIX

(www.cormix.info)

Modeling mixing characteristics of multiport diffuser using VISJET

(www.aoe-water.hku.hk/visjet/visjet.htm)

2. Numerical Modeling

Numerical modeling of suspended solids using FE method

Numerical modeling of non-conservative pollutants using FD method

3. Theoretical Study

Analytical solutions of 2D A-D equation for non-conservative substances

Analytical investigations of dispersion tensor in 2D A-D equation

Theoretical equation for dispersion coefficient based on velocity profiles in shear flows

4. Laboratory Experiments

Investigation of pollutant transport using tracer tests in meandering channels

Investigation of pollutant transport using tracer tests in confluent channels

Vertical diffusion of pollutants in varying slope channels

5. Field Study

Investigation of pollutant transport using tracer tests in meandering channels of Andong REC

Field measurements of water quality in rivers