# AE2201 Environmental Dynamics/Physical Processes 7.5 credits

## Miljödynamik/fysikaliska processer

This is a translation of the Swedish, legally binding, course syllabus.

If the course is discontinued, students may request to be examined during the following two academic years

## Establishment

Course syllabus for AE2201 valid from Autumn 2007

## Grading scale

A, B, C, D, E, FX, F

## Education cycle

Second cycle

## Main field of study

Built Environment,Environmental Engineering

## Specific prerequisites

At least three years of academic studies in an engineering programme. Basic knowledge in physics, chemistry and mathematics

## Language of instruction

The language of instruction is specified in the course offering information in the course catalogue.

## Intended learning outcomes

This course is designed to enhance student's understanding of the dynamic nature of environmental systems, and to provide her/him with basic conceptual tools for quantitative analysis of change for the most significant environmental problem areas. The course will provide the student with a unique combination of theoretical/conceptual basis for modelling environmental change, and hands-on knowledge on how to approach the modelling of complex environmental systems, natural and anthropogenic. Particular effort is focused on encouraging student participation and self-learning. Campus teaching of the course is complemented with modern on-line, interactive course material including simulation modules (applets) for individually exploring specific problems, following student's own pace and interest.

After completion of the course the student should:

- understand the basic principles for modelling and have a grasp of the dynamic nature of environmental systems;
- know what the general steps are when building mathematical models in environmental engineering;
- understand stochastic nature /randomness in natural systems and familiarize with elementary tools that are used for quantifying uncertainty;
- understand the basis of commercial modelling tools based on their documentation;
- have at least rudimentary experience with process modelling in all major areas of environmental engineering and science, from eutrophication, estuary, surface-, and groundwater water quality assessment, to climate change and anthropogenic systems.

The specific aim of the Homework Assignment is to provide the students with hands-on experience in independently solving modelling problems related to flow and quality of surface- and subsurface water.

## Course contents

The course is structured into different parts/topics plus a homework assignment.

- Why you need this course: Introduction

Students learn about the importance of quantifying environmental impact and change for sustainable development with the help of illustration examples from key problem areas of environmental science and engineering. The introduction further includes mathematical preliminaries.

- Analytical tools at our disposal: Conceptual basis and general principles

Basic definitions and principles of model development are presented. The general formulation of balance laws, i.e. conservation of mass, momentum and energy, material and energy flows and transformations are discussed. Furthermore, the probabilistic nature of environmental processes and uncertainty aspects are presented.

• Water lifeline: Streams, lakes and drainage basins

Students learn how to develop simple water flow and quality models such as box models for lakes. Students apply the 1-D advection dispersion equation to water quality issues in streams. It is shown how complex drainage-basin-scale models are developed using geographical information system (GIS) and the simple models discussed. Students learn about stochastic aspects of surface water modelling. The students apply simple tools such as first-order approximation and Monte Carlo analysis to assess the parametric uncertainty of water quality models and individually explore problems with simulation modules (applets).

• Where rivers and oceans meet: Estuaries and coastal zones

This topic deals with the physical process in the estuaries and the coastal zones. Students hear about basic definitions, principles of mixing, salt/mass balance techniques and the pollutant dispersal mechanisms in estuaries in this part. They further learn about modeling of estuaries, starting from the low dimensional 1 D models to the complex 3 D models.

• Kidneys of the water cycle: Soil and groundwater

Students obtain basic knowledge in the field of hydrogeology including an overview of anthropogenic contamination of soil/groundwater in a modern society. Further, the role of groundwater in the hydrologic cycle and important parameter/processes that describe the movement of water in subsurface environments are part of this topic. Students learn about tools to describe the flow of groundwater in porous (and fractures) media, i.e., Darcy's law, Continuity equations, and analytical and numerical approaches, and theories of solute transport in the subsurface, i.e., advection, dispersion/diffusion, retardation and reactions, with help of interactive simulation modules. This also includes statistics to describe the stochastic nature of flow and solute transport in groundwater.

• The biosphere: Eutrophication, ecosystems and global nutrient cycles

Students are introduced into the fundamental processes determining the eutrophication of lakes and the influence of limiting nutrients. This is also exemplified using the example of the Baltic Sea. The main reservoirs and exchange pathways of the global phosphorus and nitrogen cycles are discussed. The topic further includes an introduction into the modeling process, which is then applied to model lake eutrophication consisting of an aquatic phosphorus model- mass balance approach, model dynamics, different complexity levels and a sensitivity analysis of obtained results.

• Climate change: Linking atmosphere, biosphere, hydrosphere and technosphere

Students learn about the climate system, its main components and the interaction among these components (climate feedbacks). Natural and human-induced climate variations, which includes global energy balance, natural and enhanced greenhouse effect, radiative forcing, aerosols, and perturbation of the atmospheric composition, are presented. Students interactively work both with a simple carbon box model and an advanced multi-process model to investigate the impact of various parameters/processes and human activity on global warming.

• Anthropogenic metabolism - Material Flow Analysis in the Technosphere

Students are introduced into the fundamentals of material or substance flow analysis (MFA) and how man-made material flows interfere with natural material flows. Problems of natural resource depletion and environmental pollution cause by the high and steadily increasing material flows and accumulations (stocks) in our wealthy society are presented. Students will learn about how material flow analysis can be used in sustainable development.

- Summary: Are we in control?

The summary reiterates the aims of course and reflecting on achieved, which includes our efforts to control material and energy flows in the techno-sphere, navigation toward sustainable development - linking all the spheres (atmos-, bio-, geo-, hydro-, and techno-), quantitative criteria (“metrics”) for sustainable development, economic constraints and their implications, and management of natural resources.

Homework assignment:

- Part I - Students individually solve water flow and quality problems in surface waters of a small drainage basin. The assignment includes derivation of a flow model in a lake and calculation of water level changes. The students assess eutrophication problems based on a model that has to be developed using the information supplied. Furthermore, a water temperature model has to be derived and applied. The 1-D advection dispersion equation (ADE/ADR) is applied to non-reactive and reactive solute transport in streams. The students explore the parametric uncertainty of the ADE using simulation modules (applets).

Part II- In the second part students apply the balance equations of water mass (flow) for typical problems related to laboratory and field measurements of aquifer properties. This includes problems related to aquifer porosity and hydraulic conductivity derived from soil samples, field measurements and/or pumping tests. The students further calculate and explain solute transport in an aquifer by the use of analytical solutions for the 1-D advection dispersion equation (ADE/ADR). A number of simulation modules (applets) help the students to investigate and answer various questions of this assignment

## Course literature

- Course compendium "Environmental Dynamics: An introduction to modeling anthropogenic impact on natural systems" by the teachers (V. Cvetkovic and P. Martinet) and teaching assistants (C. Baresel, G. Lindgren, A. Nikolic, and S. Molin). Available both for purchase and online use.
- Handout may be provided during the course.

## Examination

- TEN1 - Examination, 1.5 credits, grading scale: A, B, C, D, E, FX, F
- TEN2 - Examination, 3.0 credits, grading scale: A, B, C, D, E, FX, F
- ÖVN1 - Project Report, 3.0 credits, grading scale: P, F

Based on recommendation from KTH’s coordinator for disabilities, the examiner will decide how to adapt an examination for students with documented disability.

The examiner may apply another examination format when re-examining individual students.

## Other requirements for final grade

Homework assignment, two parts with deadlines (ÖVN; 3 cr; [P/F])
Oral test about Homework assignment (TEN1; 1.5 cr; A/B/C/D/E/F)
Written examination (TEN2; 3 cr; A/B/C/D/E/Fx/F)
Slutbetyg (final grade) 40% TEN1 + 60% TEN2

## Ethical approach

- All members of a group are responsible for the group's work.
- In any assessment, every student shall honestly disclose any help received and sources used.
- In an oral assessment, every student shall be able to present and answer questions about the entire assignment and solution.