CE 302 HYDRAULICS

Coordinator: to be advised

Status: Core Module

Lecturer: Dr. G. R. Hunt (GRH) (Room 404)
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Structure: 50 hours of lectures and tutorials, including six hours laboratory work.

Links: see below
CE308, CE314: Strongly related
CE406, CE407, CE408: Recommended

Introduction
The module consists of three inter-related sections:
1. Dispersion of Pollution. (GRH)
2. Sediment Transport.
3. Groundwater Hydraulics. (APB)

These three components of the course are of major importance in the application of basic fluid mechanics to practical civil and environmental engineering problems in the general field of civil engineering hydraulics. Pollutants are carried in flowing waters either within the water column in free-surface flow, deposited on or contained within sediments transported in the flow and in groundwater flows. Therefore, in addition to determination of flow rates and discharges in various situations, careful consideration has to be given to pollutants, their origin, pathways and destinations. This course provides understanding and experience in the core processes involved which provide the basis for further study in the final year.

Aims
To enable students to extend their understanding in three key areas of civil and environmental engineering hydraulics and to gain experience and skills in the application of that understanding to practical situations.

Links with other course modules:
The course builds on knowledge and understanding from CE 105 (Fluid Mechanics), CE 202 (Hydraulics) and CE 204 (Environmental Engineering) courses. It relates to courses CE 308 (Computational Engineering), CE 314 (Coastal Engineering) in the current year. Various elements of the course are drawn upon in final year courses: CE 406 (Applied Hydrodynamics), CE 407 (Water and Wastewater Engineering) and CE 408 (Water Resources Engineering).

SYLLABUS
1. Dispersion of Pollution (GRH)

This section considers the mixing and transport of a discharged pollutant into a fluid environment. This will include an introduction to turbulent flow, including an examination of the time-averaged equations of motion. The physical concepts of advection and diffusion are considered and a number of engineering solutions outlined. This should enable the student to assess the dispersion of pollution in a

range of practical situations and to determine the resulting concentrations which is an essential component in environmental impact assessment.

The components of the section are:

- Concentrations, advection and bulk transport.
- Diffusion processes. (one hour)
- Simplified solutions to Advection-Diffusion. (one hour)
- Introduction to turbulent diffusion. (one hour)
- Time-averaged equations of motion. (two hours)
- Dispersion in uni-directional flows. (one hour)
- Jet dynamics. (one hour)
- Introduction to thermal plumes. (one hour)

Laboratory and Tutorials.
The section includes a short laboratory experiment which explores the combination of advection and diffusion processes in a uni-directional flow in support of the lectured material, and three hours of tutorial work.

2. Sediment Transport (PH).

This module of the course is an introduction to the transportation of sediments in uni-directional flow. Taking a realistic model of the velocity profile of the flow in the vertical, the flow-induced forces acting on bed sediments are discussed leading to the concept of a critical velocity or bed shear stress at which sediment transport is initiated. A distinction is drawn between “bed-load” and “suspended” sediment transport and methods of predicting the rates of transport in these two modes are derived. Given the complexity of the physics involved even the most modern models of sediment transport may be relatively inaccurate in practical applications. This factor is discussed in relation to real civil and environmental engineering applications.

The components of the section are:

- General Introduction. (one hour)
- Velocity profiles in uni-directional flow. (one hour)
- Properties of sediments. (one hour)
- Initiation of motion – bed load. (one hour)
- Initiation of motion – suspended sediment. (one hour)
- Prediction of bed-load sediment transport rates. (one hour)
- Prediction of suspended sediment concentrations and transport. (one hour)
- Sediment budgets and practical considerations; the variability of predictions. (one hour)

Laboratory and Computations
The section involves a laboratory experiment to determine the threshold conditions at which sediments of two sizes begin to move in a uni-directional flow and to compare the results with predicted values. It also includes an exercise using an available numerical model to explore the sensitivity of predicted sediment transport rates to variations in the major physical parameters: flow speed, depth and sediment size. Three hours of tutorial work are included in the module.

3. Groundwater Hydraulics (APB).

This module of the course will demonstrate how the complex flow of groundwater through rock voids can be simplified using continuum mechanics. The concepts of energy and mass conservation are used to develop the groundwater flow equation. This, in turn, is applied to various practical problems, particularly the hydraulics of wells. It is shown how well tests can be used to identify aquifer parameters

characterising groundwater flow and storage and to evaluate the potential of sub-surface water resources.

The components of the section are:
- Introduction to groundwater. (one hour)
- Energy and momentum concepts applied to groundwater flow. (two hours)
- Groundwater storage and derivation of the mass balance equation. (one hour)
- Steady groundwater hydraulics: potential and stream functions. (one hours)
- Steady-state well hydraulics. (one hour)
- Transient well hydraulics. (one hour)
- Groundwater resource evaluation. (one hour)

The section includes three hours of tutorial work.

Assessment
One three-hour examination, two laboratory reports (sediment transport and dispersion of pollution) and a report on numerical modelling of sediment transport. The examination paper contains both compulsory and optional questions.

Recommended Textbooks/Reading
A full set of notes is provided to students for each module of the course. These cover the entire course content and include sources of reference. Printed briefs are provided for the laboratory experiments and for the numerical study of sediment transport.

Learning Outcomes

Dispersion of Pollution. (GRH)
- Appreciate the relative importance of advection and diffusion for a range of practical applications.
- Be able to determine the appropriate model to apply to specific situations.
- Be able to solve the models for pollutant concentrations in space and time.
- Understand the significance of these processes in relation to environmental impact assessment.

Sediment Transport. (PH)
- Have an understanding of the physical process involved in sediment transport.
- Appreciate the relevance of sediment transport in civil and environmental hydraulic applications.
- Be able to predict bed and suspended sediment transport rates.
- Be able to set such predictions, including their inherent variability, into a practical context.

Groundwater Hydraulics. (APB)
- Understand the physical processes of groundwater flows.
- Be able to solve groundwater flow for a range of practical problems, particularly those relates to wells.
- Understand how to determine the characteristics of groundwater flow and storage in a practical context

Overall Learning Outcomes

- Development of knowledge and understanding of three key sectors of civil and environmental hydraulic engineering.
- Enhancement of skills in the formulation of mathematical models of the physical processes inherent to these topics.
- Development of an ability to solve those models by appropriate means.
- Improvement of skills in the interpretation of the results in a practical engineering context.