4A4 – Hydraulics [5 credits]

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Module organisation
Department of Civil, Structural and Environmental Engineering

This module runs throughout the first semester of the academic year and comprises three lectures per week for the entire period. There are three one hour associated laboratory periods and tutorials are handed out during the term for submission by the students within a two week period.

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<th>Semester</th>
<th>Start Week</th>
<th>End Week</th>
<th>Lectures</th>
<th>Tutorials</th>
<th>Practicals</th>
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Total Contact Hours: 35

Module description, aims and contribution to programme
This is a one semester module taken by Senior Sophister A Stream students. It explains the use of dimensional analysis in predicting the performance of prototypes from model studies and in the analysis of significant variables in hydraulic experiments. Methods are developed for estimating the forces set up by curved flow and these are used to predict forces and water profiles in a variety of design situations. The module reviews the important relationship of open channel flow in natural channels and uses these relationships to study the water profiles to be expected in various design situations. The module explains the concepts behind hydraulic turbines and categorises turbines in relation to the specific head and usage. The design of small scale hydro schemes is also formulated. The module develops design methods for river protection measures by analysing the stability of sediment on the river bed. The hydrology section of the course begins by describing how to quantify the water mass balance on a catchment by rainfall and evaporation measurement and analysis. The measurement of flow in rivers is then explained by various gauging methods before the concept of a hydrograph is detailed. The design technique of the Unit Hydrograph is then developed before finally explaining different methods which can be used to route a flood down through a river channel. The module also examines the behaviour of sea-water waves using linear wave theory, predicting their speed, power and energy among other factors. Students will be able to apply this theory to the design of coastal structures or wave energy devices. Finally, the module examines analysis of engineering problems involving unsteady flow, such as pressure transient in pipelines.

Learning outcomes
On successful completion of the module, students will be able:

1. To predict the performance of hydraulic prototypes from simple hydraulic models.
2. To demonstrate an understanding of open channel flow in relation to natural channels.
3. To estimate the forces set up by curved flow.
4. To categorise turbines and to design the hydraulic aspects of a small scale hydroelectric scheme.
5. To calculate the forces on sediment on the bed of a river and to design river bank slope protection measures.
6. To analyse river hydrographs and to relate the river response to rainfall data.
7. To interpret the results from a network of rain gauges and synthesise the data for use in a hydrological study of a river catchment.
8. To evaluate the translation and attenuation of a flood hydrograph down a river channel using hydrologic flood routing techniques.
9. To demonstrate an understanding of and formulate design solutions for problems involving unsteady flows.
10. To predict the transformation of waves using linear wave theory

Module content

- **Dimensional analysis and similarity**
  - Indical method and Buckingham’s theory
  - Prediction of the performance of prototypes from models
  - Simplification of experimental studies.

- **Open channel flow in Natural Channels**
  - Velocity Distributions in Natural Channels
  - Flow in Compound Channels
  - Conveyance

- **Streamlines, Flow-nets & Vortices**
  - Streamlines
  - Flow Nets
  - Free and Forced vortex

- **Turbines and hydro schemes**
  - Engineering characteristics of turbines
  - Analytical methods of predicting the performance of turbines

- **River protection**
  - Analysis of forces on sediment in rivers
  - Analytical methods of designing river protection systems

- **Hydrology**
  - Precipitation measurement and analysis
  - Evaporation measurement and calculation
  - River gauging and flow measurement
  - Hydrograph analysis
  - Unit Hydrograph
  - Flood routing.

- **Unsteady Flow**
Types of unsteady flow
Pressure Transients
Surge Towers
  - Linear Wave Theory
    - Wave transformation processes
    - Wave Energy
    - Coastal Protection

Teaching strategies
This module is taught by a combination of lectures, laboratory classes and tutorials. Three laboratory experiments are also undertaken, one looking at the efficiency of a Pelton Wheel, another looking at flood routing and unit hydrographs, the last examining pressure transients. These are directly related to material covered in the module and enable the student to experience the practical application of the theoretical analysis of the lectures. Practicals have to be written up and handed in by the end of the first term. Continuous assessment in this module also comprises a number of tutorial assignments and a field trip report.

Assessment
Assessment is by written exam and laboratory experimental reports, field trip reports and tutorials. The examination counts for 75% of the final mark together with a further 25% contribution from the laboratory practicals and tutorials. The examination questions are designed to test the students ability to use the knowledge gained in lectures to solve practical problems. The examination is two hours long and students are expected to answer three questions. The laboratory experiments are used to illustrate particular areas of hydraulics which are also covered in the lectures.

Required textbook
*Hydraulics in civil and environmental engineering* - Chadwick & Morfett (E & FN Spon)
*Hydrology in practice* – Shaw (Chapman & Hall)
*Engineering Hydrology* – Wilson (Scholium International)
*Mechanics of Fluids* – Massey (Taylor & Francis)