Hydraulics – Hydrology

MODULE TITLE	Hydraulics - Hydrology
LECTURER(S)	Dr Ivetic and Dr Mamassis
ECTS VALUE	8
PREREQUISITES	Physics, Geography, Mathematics
COREQUISITES	
DURATION OF MODULE	15 weeks

TOTAL STUDENT STUDY TIME

Overall, the module is expected to involve students in approximately 200 hours of learning: 12 5-hour lectures; 58 hours assignments; 78 hours private study; 4-hour examination.

WEB LINK http://www.water-msc.org/en/wrem101.htm

AIMS

This module aims to provide a basic knowledge of hydraulics and hydrology (or to organize existing knowledge) for the practising engineer. It provides the ability to solve engineering problems of fluid flow in pipes and open channels by application of basic hydraulic principles and engineering tools in the process of engineering analysis and design. Also, it provides basic understanding of flow control and flow measurement in open channels, and it develops the ability to determine energy losses and flow capacity of basic hydraulic structures. It provides a basic knowledge of atmospheric and surface processes (precipitation, evapotranspiration, soil moisture, infiltration, surface runoff). It offers gaining practical experience on hydrological data acquisition, analysis and interpretation on temporal and spatial scales of hydrological processes and on using simple catchment rainfall-runoff models.

INTENDED LEARNING OUTCOMES

1. Subject Specific Knowledge, Understanding and Skills

By the end of this module, the students should:

a) understand the physical and mathematical fundaments of hydraulics;
b) understand the basics of flow control and flow measurements;
c) be able to determine the influence of basic hydraulic structures on flow in open channels (energy losses, backwater effects etc.);
d) understand the physical and mathematical fundaments of hydrology;
e) have a broad overview of hydrological science and water resource issues;
f) manage and process hydrological and meteorological measurements;
g) apply hydrologic principles to water related problems;
h) manage hydrologic applications using software.

2. Core Academic Skills

By the end of this module, the students should:

a) be able to identify, formulate and analyse hydraulic and hydrological problems;
b) be able to critically assess research results;

c) have acquired some practical experience of using hydrological data and modelling tools;
d) have acquired an understanding of the impact of solutions for civil engineering works in a global and societal context.

3. Personal and Key Skills

By the end of this module, the students should have:

a) improved further the necessary skills for independent learning;
b) enhanced report and presentation skills;
c) enhanced using of spreadsheets and geographical information systems (GIS);
d) acquired an ability to function in multi-national teams.

LEARNING/TEACHING METHODS

Lectures, problem sheets, computer based problem solving, tutorials.

ASSIGNMENTS

Two assessed coursework assignments (2,500 equivalent words each including graphs and tables).
Problem sheets computer based problem solving.

ASSESSMENT

Examination paper (60%), Course work (40%)
3-hour examination - use of notes and book allowed
2 assignments on practical application of modelling tools (2*20% = 40%, 5,000 equivalent words, including graphs and tables)

SYLLABUS PLAN

1. **Introduction to Hydraulics:** Natural Fluid Motions: rivers and streams, earth surface flow, ground water flow. Hydraulic Engineering: Flow in pipelines, canals, sewers. Units and Dimensions; Physical properties of fluids (density, viscosity, compressibility, surface tension and the capillary effect, specific heat and thermal conductivity).
2. **Forces in fluids and fluid in motion:** Body forces and Surface forces. Fluid statics; Pressure and force; Pressure head; The equation of Hydrostatics; Piezometric head; Measurement of pressure; Constant density, Different fluids, Thermal stratification and environmental consequences. Kinematics of fluid motion: velocity of a fluid particle, streamlines, pathlines and streaklines, average velocity. Shear stresses and viscosity. Laminar and Turbulent flow; Reynolds number.
3. **Conservation laws:** Control volume and control surface; Conservation of mass – continuity equation. Conservation of momentum – dynamic equation; Conservation of mechanical energy – Bernoulli equation. Differential forms of conservation laws.
4. **Uniform flow:** Flow resistance, Wall roughness, Pipe flow; Minor losses. Distribution networks; Open channel flow. Chezy-Manning equation. Roughness, Channel capacity.
5. **Non-uniform flow:** Specific energy and flow regimes. Basic equations. Gradually varied flow profiles. Standard-step method for flow profile calculation. Hydraulic jump. Control sections.
6. **Hydraulic structures and flow control**: Hydraulic structures and flow control; Weirs, gates, dropstructures etc.; Flow measurement; direct (volumetric, integration over cross section) and indirect methods. (Venturi flume, orifice flow meter, sharp-crested, broad crested weirs etc.)

7. **Unsteady flow in open channels:** Simplified forms of equations. Level-pool routing, Cunge-Muskingum method; Method of characteristics for rapid flow changes.
8. **Introduction to Hydrology:** Definition and introduction to hydrological science, brief history, structure and properties of water, the earth-atmosphere system and the hydrological cycle, radiation in the atmosphere – energy budget, water in the air (evaporation and condensation), hydrological measurements, quantification of hydrological variables.
9. **Precipitation:** Physical and meteorological context, temporal and spatial distribution of precipitation, precipitation measurement, elementary data analysis. Special issue: use of Geographical Information Systems for areal estimation of precipitation.
10. **Evaporation and Infiltration:** Physical and meteorological context of evaporation, meteorological measurements, estimation of evapotranspiration, physical context of infiltration, losses estimation (SCS, index phi). Special issue: use of Geographical Information Systems to areal estimation of radiation.
11. **Runoff:** Runoff generation and processes, hydrological basin characteristics, streamflow measurements and rating curves, hydrographs, estimation of flood peaks (rational method, unit hydrograph).
12. **Hydrological Models:** Introduction to hydrological modelling, classification of hydrological models, conceptual models (Thornthwaite's simple water budget model), distributed models, model manipulation (calibration, verification). Special issue: use of Zygos model

INDICATIVE BASIC READING LIST

1. Ligget J.A., Caughey D.A., 1998, Fluid Mechanics - An Interactive Course, ASCE.
2. Henderson F.M., 1966, Open Channel Flow, The Macmillan Company.
3. Dingman, S.L., Physical Hydrology (2nd ed.). Prentice Hall., 2002.
4. Maidment, D.R. (editor), Handbook of Hydrology. McGraw-Hill, New York, 1993
5. Chow, V. T., D. Maidment, and L. W. Mays, Applied Hydrology, McGraw Hill, 1988.

EXTENDED READING LIST

1. Linsley, R., M. Kohler, and J. Paulhus, Hydrology for Engineers, McGraw Hill, 1975.
2. McCuen, R. H., Hydrologic Analysis and Design, Prentice Hall, 1989; 2nd Edition.
3. Sthraler A. and Sthraler A., Physical Geography, (3rd ed.), John Willey and Sons, Inc., 2005.

AUTHORS

1. Marko Ivetic, Professor, University of Belgrade
2. Nikos Mamassis, Lecturer NTUA