Engineering Tripos Part IIA, 3D5: Hydraulics, 2025-26

Module Leader

Prof D Liang [1]

Lecturer

Dr E Borgomeo [2]

Lecturer

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Lecturer

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Lab Leader

Prof D Liang [1]

Timing and Structure

Michaelmas term. 16 lectures and coursework.

Aims

The aims of the course are to:

- Explain some fundamental principles necessary for understanding the common water issues in the world.
- Introduce the basic topics in water resources, open channel flows and groundwater flows.
- Allow students to grasp essential concepts and procedures for analysing hydro-environmental processes and develop skills to solve practical water engineering problems.
- Highlight some of the most pressing water-related global challenges, such as freshwater scarcity, soil erosion, water quality deterioration and flooding, and stress the need for sustainable and integrated management of water resources.

Objectives

As specific objectives, by the end of the course students should be able to:

- Comprehend the scope of water-related topics in civil and environmental engineering
- Appreciate the environmental, social, political and economic implications of water engineering and hydraulic engineering projects
- Understand the hydrologic cycle and the water budget
- Promote nature-based and nature-friendly solutions to water-related problems
- Understand the soil properties and simple models of ground infiltration
- Determine the steady seepage patterns in the porous media

- Evaluate potentials, pore water pressures, and flow quantities in the ground by constructing flow nets
- Calculate the seepage below concrete dams and through embankment & earth dams
- Analyse topics on excavations and seepage, cofferdams and stability
- Draw parallels between groundwater flow and heat flow in porous media
- Understand river hydraulics
- Solve steady flows using the equations of mass, energy and momentum conservations

Content

Hydrology and Water Resources (3L) 2 lectures/week, weeks 1-2 (Dr Borgomeo)

- Global water issues
- Hydrologic cycle
- Water resources

Groundwater, Seepage and Heat Flow in Granular media (8L), 2 lectures/week, weeks 2-6 (Prof SPG Madabhushi)

- Concept of porous media and bulk properties.
- Definitions of potential head, pressure head and pore pressure.
- Groundwater flow and seepage
- Theory of flow nets
- Anisotropic soils and flow nets
- Darcy's law and Hydraulic conductivity
- Laboratory and in situ measurements
- Seepage below concrete dams
- Seepage through embankments and earth dams
- Stability and seepage around excavations
- Coffer dams and their stability
- Fourier’s law and heat flow in porous media
- Parallels between ground water flow and heat flow
- Ground source heat pumps
- Storage and extraction of heat from ground

Open Channel Flows (5L) 2 lectures/week, weeks 6-8 (Prof D. Liang)

- Boundary layer and turbulence
- Flow resistance
- Steady flow in open channels
- Backwater curves
- Water surface profiles in non-uniform flows

Coursework

Labs on underground water and heat flow will take place in Inglis Building Structures Lab, which can be accessed through the big double doors on the Peterhouse roadway or through the corner of the Hydraulics Lab. Sign-up page (http://to.eng.cam.ac.uk/teaching/apps/cuedle/index.php?context=3D5 [5]) is activated at the start of Michaelmas. Lab reports should be submitted on the 3D5 Moodle page within 15 days after the experiment.

Learning objectives:

- Axi-Symmetric flow of ground water into a well boring
- Axi-Symmetric heat flow in saturated soil

Practical information:

- The Structures Lab is adjacent to the Robotics Lab.
- This activity doesn't involve preliminary work, but it will be beneficial to read the handouts beforehand.

Full Technical Report:

Students will have the option to submit a Full Technical Report. FTRs can be based on the 3D5 Lab or be an essay on any water engineering issues. FTRs should be submitted on the 3D5 Moodle page. More information on the possible FTR topics will be given in the first lecture.

Booklists

Please refer to the Booklist for Part IIA Courses for references to this module, this can be found on the associated Moodle course.

Examination Guidelines

Please refer to Form & conduct of the examinations [6].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [7] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

D1

Wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations.

S1

The ability to make general evaluations of commercial risks through some understanding of the basis of such risks.

S3

Understanding of the requirement for engineering activities to promote sustainable development.

S4

Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US3

An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

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