CE202 FLUID MECHANICS

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Structure: A series of lectures and tutorials extending over the Autumn and Spring Terms will be complemented by three laboratory sessions. Work undertaken in the Autumn term will also contribute to a a 2-day design project (CE209).

Links: See below

Introduction
The importance of water to mankind is reflected in the heavy involvement of civil engineers in all aspects of the water industry. In domestic and industrial situations we are concerned with two parallel processes for collecting, treating, transporting and dispersing fresh water on the one hand and polluted water on the other. We design reservoirs, intakes and canals to irrigate thirsty lands. Where there is too much water, pumping schemes are developed for land drainage.

We create platforms to exploit natural resources in a hostile marine environment. Estuary defences such as the Thames Barrier and coastal protection systems - seawalls and groynes - hold back the waves and tides. Civil engineers dam rivers for water supply, power generation and flood protection. Within this wide field the module concentrates on descriptions of waves and wave loading, on closed circuit (pipe) and open channel flows and on hydraulic structures.

Aims
The module builds on the Fluid Mechanics module of the First Year. The Autumn term lectures aim to show how gravity waves can be described mathematically and how their loadings on offshore structures can be predicted. The Spring term builds directly on the First Year, introducing real fluids and steady flow in pipes, pipe systems and open channels. It concludes with an introduction to the local conservation equations

Links with other course modules
The module leads on to the Hydraulics core module and Coastal Engineering option of the Third Year and to Applied Hydrodynamics and Environmental Fluid Mechanics options of the Fourth Year. The two day design project (CE209) is based upon work undertaken in the Autumn term and involves both fluid and structural considerations in the design of a Tension-Leg Platform, TLP.

SYLLABUS
The Autumn Term lectures (CS) will address the following topics:
1. The fundamental description of a flow field (Eulerian vs. Lagrangian).

2. Velocity potentials and the concept of irrotationality.
3. The unsteady energy equation.
4. Linear wave theory.
5. Second order effects: wave energy, mass transport, and group velocity.
6. Waves advancing into shallow water.
7. Fluid loading: an introduction to drag and inertia forces.
8. Wave loading: the application of Morison's equation and the importance of the Keulegan-Carpenter number.

The Spring Term lectures (RJS) will cover the following topics:

1. Real fluids. (Fluid shear, Newton's law of viscosity.)
2. Laminar and turbulent flow. (Reynolds experiment, stability, Reynolds number, Reynolds stress.)
3. Steady pipe flow. (Boundary resistance, Moody diagram, minor losses, boundary layer profile.)
4. Pipe systems. (series, pumps, parallel, branched, networks.)
5. Gradually varied flow in open channels. (Natural channels, uniform flow, water surface profiles.)
6. Local conservation equations. (Introduction to the next level.)

Revision sessions for each part of the module will take place in the Summer Term.

Coursework
In the Autumn term the coursework will involve a laboratory session in which students will investigate the physical properties of a number of progressive wave trains and will undertake related design calculations.

In the Spring Term, there will be four coursework assignments, respectively on
i. Real Fluids, Laminar & Turbulent Flow
ii. Steady Pipe Flow
iii. Pipe Systems
iv. Gradually Varied Flow in Open Channels
and two laboratory assignments, respectively on
a. Pipe friction
b. Turbulent boundary layers

Assessment
The laboratory and coursework assignments will be assessed for a coursework mark. The Fluid Mechanics examination at the end of the session will consist of eight questions covering each half of the module from which five are to be chosen.

Recommended Textbooks
DEAN and DALRYMPLE, Water Wave Mechanics for Engineers and Scientists
HAMILL, Understanding Hydraulics
HENDERSON, Open Channel Flow
MUNSON et al., Fundamentals of Fluid Mechanics
PNUELI and GUTFINGER, Fluid Mechanics
SABERSKY et al., Fluid Flow: A First Course in Fluid Mechanics
SMITS, A Physical Introduction to Fluid Mechanics

Learning Outcomes
The tutorial, laboratory and coursework submissions, and the examination in June will provide an indication of your understanding of the fundamental physics of fluid flows. Specific examples will concern gravity waves, and the flow in pipes and open channels. By the end of the module you should be able to prepare simplified outline designs for a wide range of hydraulic structures and to estimate the wave loads on offshore platforms.