UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Fluid Dynamics in Geosciences and Geohazards

2627-1-F7402Q047

Module description

1. INTRODUCTION TO THE TOPICS (about 4 hours)
   1.1 Fluids in Earth Sciences: the interior, the hydrosphere, the atmosphere
   1.2 Basic physics and Newton's equations
   1.3 What is a fluid? A microscopic view aids understanding complex equations
   1.4 Fluid statics: the law of pressure in the gravity field
2. FLUIDS: PROPERTIES AND DESCRIPTION (about 8 hours)
   2.1 Kinetic view of fluids
   2.2 The laws of fluid mechanics (1): fluids are conserved (the continuity law)
   2.3 The laws of fluid mechanics (2): fluids follow Newton's law (the Navier-Stokes equation)
   2.4 Boltzmann equation and fluid dynamics
   2.5 Properties and behaviour of the two most important fluids on Earth: water and air
   2.6 Dimensionless numbers in fluid mechanics of particular interest for Earth Sciences: the Froude number
   2.7 The Reynolds number and the origin of turbulence
   2.8 Simplified views on fluid mechanics with special emphasis on the Bernoulli equation for non-viscous flows
   2.9 The Stokes regime, or why clay in water and clouds droplets in air remain suspended
   2.10 Forces between solid particles and fluids: the drag force
3. NEWTONIAN AND NON-NEWTONIAN FLUIDS (about 4 hours)
   3.1 The laws of fluid mechanics (3): constitutive laws for Non-Newtonian fluids
   3.2 The science of rheology
   3.3 Examples of non-Newtonian fluids
   3.4 Flow of Newtonian, Bingham, and Herschel-Bulkley fluids along a slope
4. APPLICATION TO RIVER FLOW, HYDRAULICS, AND PHYSICAL SEDIMENTOLOGY (about 6 hours)
   4.1 Application of fluid mechanics to open channel flows; hydraulics; the de Saint-Venant equations
   4.2 River flow
   4.3 A few notes on river geomorphology and erosion
   4.4 Floods
   4.5 Dam breaks and catastrophic emptying of glacial lakes, GLOFs

4.6 Hyperconcentrated flows
4.7 Numerical simulations of dam breaks
4.8 Extremely catastrophic natural dam breaks: the case of the Channelled Scablands
4.9 Applications to physical sedimentology: dunes, antidunes, transport of sediments

5. APPLICATION TO LANDSLIDES, DEBRIS FLOWS, AND OTHER MASS FLOW HAZARDS (about 6 hours)
   5.1 Types of landslides and mass flows
   5.2 Debris flows
   5.3 Mudflows and lahars
   5.4 Numerical simulations of debris flows
   5.5 Granular media as a highly dissipative fluid: granular temperature and the Haff equation
   5.6 Application to rock and granular avalanches
   5.7 Mass flows falling onto large water reservoirs (natural of artificial)
   5.8 Snow avalanches: different types, entrainment, powder snow avalanches
6. SUBAQUEOUS MASS FLOWS AND COASTAL HAZARDS (about 6 hours)
   6.1 The ocean environment
   6.2 Waves: their generation; period and wavelength; dispersion relation
   6.3 Instability of the ocean environment and subaqueous mass movements
   6.4 Tsunami generation
   6.5 Shallow water approximation
   6.6 The propagation of tsunami waves; refraction
   6.7 Suspension flows and turbidity currents
7. SLOW FLOWS (about 6 hours)
   7.1 The flow of glaciers; glacial erosion
   7.2 Flow in porous and fractured media
   7.3 Lava flows
   7.4 Thermal convection in the Mantle
8. SPECIAL TOPICS (about 10 hours)
   8.1 Magnetohydrodynamics and generation of Earth’s magnetic field
   8.2 Brief notes on hurricanes and tornadoes
   8.3 Fluids in a rotating Earth. Poincaré, Rossby, and Kelvin waves.
   8.4 Tidal forces and response of fluid surface in response to tidal forces

Learning goals

The objective of this course is to present the most important topics in the physics of fluids, and apply these laws to fluids in Earth Sciences. Examples and case studies will illustrate aspects of fluid mechanics in geology and geohazards.

General goal

La maggior parte delle lezioni mira a semplificare le complessità della meccanica dei fluidi a livello pratico. Allo stesso tempo, spiegheranno la fisica alla base dei calcoli dei software di fluidodinamica computazionale.

Specific skills and competences

Some basic physics and mathematics prerequisites are required. Student must have a sufficient knowledge of mechanics, trigonometry, and calculus.

Sustainable Development Goals of the 2030 UN Agenda

goal 4

Breakdown of meetings

2 hours

Number of participants

unknown

Language used in meetings

english/italian

Delivery period of the module

2 semester

Methods of assessing the outcomes of the learning process

exam

Department of affiliation of the teacher

Sustainable Development Goals

QUALITY EDUCATION