250336 - HIDHID - Hydraulics and Hydrology

Coordinating unit: 250 - ETSECCPB - Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering
Academic year: 2017
Degree: BACHELOR'S DEGREE IN GEOLOGICAL ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
ECTS credits: 9
Teaching languages: Catalan

Teaching staff
Coordinator: MARTI SANCHEZ JUNY
Others: ENRIQUE BONET GIL, DANIEL NIÑEROLA CHIFONI, MARTI SANCHEZ JUNY

Opening hours

Timetable: The Monday morning from 10 am to 14 pm Outside these hours by appointment with the teacher.

Degree competences to which the subject contributes

Specific:
4062. Knowledge of the principles of fluid mechanics and hydraulics

Transversal:
588. SUSTAINABILITY AND SOCIAL COMMITMENT - Level 1. Analyzing the world’s situation critically and systemically, while taking an interdisciplinary approach to sustainability and adhering to the principles of sustainable human development. Recognizing the social and environmental implications of a particular professional activity.
592. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 2. Using strategies for preparing and giving oral presentations. Writing texts and documents whose content is coherent, well structured and free of spelling and grammatical errors.
596. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.
599. EFFECTIVE USE OF INFORMATION RESOURCES - Level 3. Planning and using the information necessary for an academic assignment (a final thesis, for example) based on a critical appraisal of the information resources used.
602. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.
584. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
250336 - HIDHID - Hydraulics and Hydrology

Teaching methodology

The course consists of 6 hours per week of classes in the classroom.

Depending on the week, will be devoted 3 or 4 sessions to theoretical classes. There the teacher explains the concepts and basic materials of the subject, presents examples and exercises.

The rest of the week is complemented 2 or 3 sessions for solving problems with greater interaction with students. Exercises are conducted to consolidate the general and specific learning objectives.

Support materials used in the form of detailed educational plan through the virtual campus ATENEA: content, programming and evaluation activities directed learning and literature.

Learning objectives of the subject

Students will acquire an understanding of hydraulics and hydrology, learn how these disciplines apply to pressurised flow and free surface flow, and use them to solve technological problems.

Upon completion of the course, students will be able to: 1. Apply equations of fluid motion to engineering problems involving pressurised and free surface flow;

2. Solve problems involving pipe networks that contain additional elements such as elbows and valves;

3. Analyse open-channel water flow in basic geometries and conditions.

Fluid properties: Compressibility, viscosity, phase change and surface tension; Hydrostatics and interaction with walls and submerged objects; Equations of fluid motion and their application to conduit flow; Continuity, quantity of motion, Bernoulli's trinomial; Turbulent motion and Reynolds number; Pipe flow, conservation of energy and load loss analysis; Analysis of pump performance using characteristic curves; Variable flow in pipes; Permanent flow in free-falling nappe and application to channel performance; Erodible channel behaviour; Dimensional analysis; Laws of similarity; Basic aspects of surface hydrology; Free surface movement: Gradually and rapidly varied flow; Waves; Basic aspects of aerodynamics

Study load

<table>
<thead>
<tr>
<th>Total learning time: 225h</th>
<th>Hours large group: 52h</th>
<th>23.11%</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group: 22h</td>
<td>9.78%</td>
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<tr>
<td></td>
<td>Hours small group: 16h</td>
<td>7.11%</td>
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<tr>
<td></td>
<td>Guided activities: 9h</td>
<td>4.00%</td>
</tr>
<tr>
<td></td>
<td>Self study: 126h</td>
<td>56.00%</td>
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</table>
# Content

<table>
<thead>
<tr>
<th>Introduction to the subject</th>
<th>Learning time: 2h 24m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 1h</td>
</tr>
<tr>
<td></td>
<td>Self study: 1h 24m</td>
</tr>
</tbody>
</table>

**Description:**
- Objective of the course:
  1. Differentiation between surface hydrology and hydraulics
  2. Organization
  2.1 Characterization of theoretical and practical sessions
  2.2 Student commitment and work
  2.4 Assessment methodology
  2.3 Bibliography
  2.4 Documentation

**Specific objectives:**
Presentation and description of the course.

<table>
<thead>
<tr>
<th>Fluid properties</th>
<th>Learning time: 2h 24m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 1h</td>
</tr>
<tr>
<td></td>
<td>Self study: 1h 24m</td>
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</table>

**Description:**

**Specific objectives:**
At the end of the session students should understand the main concepts that allow the differentiation between different fluids.
**Fundamental equations**

<table>
<thead>
<tr>
<th>Learning time: 12h</th>
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<tbody>
<tr>
<td>Theory classes: 3h</td>
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<tr>
<td>Practical classes: 2h</td>
</tr>
<tr>
<td>Self study: 7h</td>
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</tbody>
</table>

**Description:**
- Description of the movement. Trajectories and lines of supply. Volume control and flow tube. Concept of flow.
- Continuity equation applied to a pipe flow
- Concept of momentum applied to a fluid. Application to a stream tube. Particularization to the case of steady flow and incompressible fluid. Boussinesq coefficient
- Application to full conduit and open channel flows. Power of the flow through a section. Laminar and turbulent motion: experience Reynolds
- Practical session of any exercise that allow to work with the fundamental equations of fluids.

**Specific objectives:**
- Students must understand the physical meaning of continuity equation mainly in the case of steady flow.
- Students must understand the physical meaning and how the equation applies to the particular case of steady flow and incompressible fluid.
- Students must understand the physical meaning of the equation of energy in fluids and how it is applied in the case of steady and incompressible fluid in a full conduit and open channel flow.
- Relate theoretical concepts to practical engineering.

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**Hydrostatics**

<table>
<thead>
<tr>
<th>Learning time: 14h 23m</th>
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<tbody>
<tr>
<td>Theory classes: 2h</td>
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<tr>
<td>Practical classes: 4h</td>
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<tr>
<td>Self study: 8h 23m</td>
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</tbody>
</table>

**Description:**
- General equation of hydrostatics applied to Earth's gravitational field. Case of a fluid under uniform and linear acceleration (relative motion). Absolute and relative pressure. Push concept.
- Concept of center of pressure. Computation of the center of pressure of a flat surface
- Horizontal and vertical components of the hydrostatic push.
- Archimedes' Principle. Concept of underpressure.
- Practical session of any exercise to work with the concepts of hydrostatics

**Specific objectives:**
- The student must understand the concepts of absolute and relative pressure and the concept of hydrostatic push.
- Establishing the basics for obtaining the hydrostatic push on flat surfaces.
- Practical determination of hydrostatic push on curved surfaces.
- Introduction of the concept of the underpressure in the contact structure - ground, a basic concept in civil engineering. The concept will be introduced by illustrating it in a practical way by solving a real problem.
- Relate theoretical concepts with practical engineering.
Full conduit flow

<table>
<thead>
<tr>
<th>Learning time:</th>
<th>26h 24m</th>
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<tbody>
<tr>
<td>Theory classes:</td>
<td>7h</td>
</tr>
<tr>
<td>Practical classes:</td>
<td>2h</td>
</tr>
<tr>
<td>Laboratory classes:</td>
<td>2h</td>
</tr>
<tr>
<td>Self study:</td>
<td>15h 24m</td>
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Full conduit flow

**Description:**

**Specific objectives:**
Review of basic equations and approach to the formulation of energy losses in pipe. Students should understand the concept of distributed energy losses and its practical determination. Students should understand the concept of local energy losses and its practical determination. Presentation of basic concepts and calculations for designing a pumping facility in steady flow. Relate theoretical concepts to practical engineering. Introduce students to the basics on transients in pipes.
### Open channel flow

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<th>Description:</th>
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<th>Learning time:</th>
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<tbody>
<tr>
<td>86h 24m</td>
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<tr>
<td>Theory classes: 19h</td>
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<tr>
<td>Practical classes: 9h</td>
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<tr>
<td>Laboratory classes: 8h</td>
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<tr>
<td>Self study: 50h 24m</td>
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### Description:

- Type of channels
- Velocity distribution
- Boussinesq and Coriolis coefficients
- Pressure distribution
- Concept of uniform flow
- Manning equation
- Determination of the Manning coefficient
- Concept of specific energy
- Curves y-E0 for a given Q
- Curves y-Q for a given E0
- Correspondence between the two curves
- Concept of critical regime and control section
- Physical significance of subcritical and supercritical regimes
- Concept of hydraulic jump
- Concept of specific force
- Minimum specific force
- Belanger's Formula
- Hydraulic jump in non-prismatic or non-rectangular channels
- Submerged and forced hydraulic jump
- Gradually varied flow in prismatic channels
- Backwater profiles
- Definition of M, S, C, H or A channels
- Curves Type M
- Gradually varied flow in prismatic channels
- Curves type S, C, H and A
- Practical session that allows the analysis of water surface profile in prismatic channels

### Specific objectives:

- Numerical solution of the gradually varied flow
- Step Method direct and inverse
- Hypotheses rapidly varied flow
- Changing the width of a channel, sudden expansions and contractions
- Venturi Channel
- Storm-meter
- Design transition gradual expansions and contractions
- Practical Session to discuss any exercise that allows the hydraulic behavior of channels with sudden changes of its geometry
- Overview of the HECRAS software
- Overview of the HEC-RAS software
- Holes and sluice gates
- Free overfall in drop structures
- Sharp crested drop structures
- Overflows the lip end of triangular section
- Spillway lip thick
- Profiles strict
- Channels design
- Hydraulically efficient section
- Suitable velocities
- Freeboard
- Practical Session to discuss the flow rate determination
- Reduced models theory
- Concept Similarity
- Geometrical, kinematic and mechanical similarities
- Froude similarity
- Scale effects
- Basic concepts
- Saint Venant equations
Introduction of basic concepts in open channel flow
Understanding the concept of uniform flow and its calculation.
Discussion of the concepts of specific energy and subcritical and supercritical regime
The student should assimilate the concept of hydraulic jump.
Analysis of the types of channels depending on the slope, geometry and flow rate. Qualitative description of the free surface profile.
Profile of the the free surface in channels type S, C, H and A.
Relate theoretical concepts to practical engineering.
Introduce students to the most common methods of calculating the profile of the foil Aiga, from solving the equation of energy.
Resumed Session 21 once entered the concepts needed to understand the practical discussion of the location of a projection along a water channel.
Familiarize the student with el comportament sudden changes in hydraulic geometry of a channel. Discussion based on the specific energy curves.
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Relate theoretical concepts to practical engineering.
Introduce the students the HECRAS software. The session will take place in the computer room.
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Introduce students to the methodologies for determining the flow rate in a channel.
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Introduce students to the methodologies for determining the flow in a channel.
Introduction of the fundamental criteria for channels design.
Relate theoretical concepts to practical engineering.
Approaches the fundamental concepts from a practical point of view of the reduced models theory. A visit to the laboratories of the Division of Hydrologic and Hydraulic Engineering of the UPC will be done.
Introduce students to basic concepts about unsteady open channel flow.
## Surface Hydrology

**Description:**
- IDF Synthetic. Synthetic Hietograms: alternate blocks method.
- Interception losses. Evapotranspiration. Depression storage losses.
- Infiltration losses. Horton method, lineal method, Fi index method Fi. SCS curve number method.
- Practical session to determine net rainfall.
- Concept of unit hydrograph. Fundamental Hypotheses.
- Clark unit hydrograph. SCS unit hydrograph. Unit hydrograph for a rainfall duration $D'$ from one of duration $D$.
- Practical application of the concept of unit hydrograph.
- Concept of routing in channels and reservoirs. The concept of lamination. Muskingum method. Modified pulse method.
- Practical application of classical methods of routing hydrographs.
- Introduction to the simulation tool "Hydrological Modeling System (HMS)."
- Discussion of real cases about obtaining flood hydrographs in natural basins.

**Specific objectives:**
- Introducing the surface hydrology in the context of the subject. Review and discuss some of the basic concepts about the rainfall formation and its measurement.
- Consider the basic concepts about the rainfall formation and its measurement.
- Presentation of the fundamental engineering concept of return period. Its application in the characterization of precipitation for the design of hydraulic infrastructures.
- Discussion of the various processes that cause losses in rainfall during the transformation into runoff.
- Relate theoretical concepts to practical engineering.
- Discussion on the unit hydrograph method of transformation of rainfall into runoff, which is fundamental in classical surface hydrology.
- Definition of classical synthetic unit hydrographs.
- Relate theoretical concepts to practical engineering.
- Presentation of the concepts of routing and lamination and different methodologies to calculate them.
- Practical application of rational method, simplified method for obtaining peak flow.
- Relate theoretical concepts to practical engineering.

**Learning time:** 72h
- Theory classes: 15h
- Practical classes: 9h
- Laboratory classes: 6h
- Self study: 42h
The mark of the course is obtained from the ratings of continuous assessment. Continuous assessment consist in several activities, both individually and in group, of additive and training characteristics, carried out during the year (both in and out of the classroom).

The evaluation tests consist of a part with questions about concepts associated with the learning objectives of the course with regard to knowledge or understanding, and a part with a set of application exercises.

The final grade is the weighted average: \( NF = 0.7 \cdot NP + 0.3 \cdot NA \) where NA is the average obtained in the regular assessment exercises, NP is the averaged mark obtained in practical exercises. Students also will develop some supervised activities to be assessed. An average mark will be obtained (NT). This will affect the final grade (NF), at most one additional point.

Criteria for re-evaluation qualification and eligibility: Students that failed the ordinary evaluation and have regularly attended all evaluation tests will have the opportunity of carrying out a re-evaluation test during the period specified in the academic calendar. Students who have already passed the test or were qualified as non-attending will not be admitted to the re-evaluation test. The maximum mark for the re-evaluation exam will be five over ten (5.0). The non-attendance of a student to the re-evaluation test, in the date specified will not grant access to further re-evaluation tests. Students unable to attend any of the continuous assessment tests due to certifiable force majeure will be ensured extraordinary evaluation periods.

These tests must be authorized by the corresponding Head of Studies, at the request of the professor responsible for the course, and will be carried out within the corresponding academic period.

Regulations for carrying out activities

Failure to perform a continuous assessment activity in the scheduled period will result in a mark of zero in that activity.
Bibliography

Basic:


Complementary: