



IDENTIFYING DATA

Resources, installations and hydro-power plants

Subject	Resources, installations and hydro-power plants			
Code	V09G311V01309			
Study programme	Grado en Ingeniería de los Recursos Mineros y Energéticos			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	Spanish Galician English			
Department				
Coordinator	Conde Fontenla, Marcos Molares Rodríguez, Alejandro			
Lecturers	Conde Fontenla, Marcos Molares Rodríguez, Alejandro Vence Fernández, Jesús			
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General description	The main goal of this course is to acquire the scientific knowledge and the study of the technical application concerning energy conversion devices that employ water as the exchanger fluid. The application of fluid mechanics to hydropower systems is revisited here from an industrial point of view, dealing with the most common types of water pumps and turbines.			

Training and Learning Results

Code	
B1	Scientific and technical training and qualification as a Mining Engineer and knowledge of the functions of consultancy, analysis, design, calculus, project, construction, maintenance, preservation and exploitation.
B2	To be familiar with the multiple technical and legal factors involved in the process of development, within the field of mining engineering, with the knowledge acquired in accordance with section 5 of order CIN/306/2009, pertaining to geological and mining prospecting and investigation, the explorations of all sorts of geological resources, including groundwater, underground construction, underground storage, treatment and benefit plants, energy plants, mineral processing and steel and iron plants, building materials plants, carbon chemistry, petrochemistry and gas plants, waste treatment and tributary plants, explosives factories, and ability to use well-tested methods and accredited technologies, with the aim of achieving the highest efficiency and ensuring the protection of the Environment and the safety and health of workers and users.
B4	Ability to design, plan, run, inspect, sign and manage projects, plants or facilities, within their field.
B6	Ability to maintain, preserve and exploit projects, plants and facilities, within their field.
C45	To know, understand and use the principles of hydraulic works and facilities. Planning and management of hydraulic resources.
D1	Ability to draw links between the different elements of all the knowledge they acquired, understanding them as components of a body of knowledge with a clear structure and strong internal cohesion.
D2	Ability to develop a project to completion in any field of this branch of engineering, combining appropriately the knowledge acquired, consulting the relevant sources of information, carrying out any required inquiries, and joining interdisciplinary work teams.
D3	To suggest and develop practical solutions, using the relevant theoretical knowledge, to phenomena and problems-situations of ordinary reality that are specific to engineering, developing appropriate strategies.
D4	To foster collaborative working, communication, organization and planning skills, along with the ability to take responsibilities in a multilingual, multidisciplinary work environment that promotes education for equality, peace and respect for fundamental rights.

- D5 To be familiar with the relevant sources of information, including constant updating, in order to practice one's profession competently, accessing all the present and future tools of information search, constantly adapting to technological and social changes.
- D10 To become aware of the need for continuous training and the constant improvement of quality, developing the values that are characteristic of scientific thinking, showing flexible, open and ethical attitudes in the face of different situations and opinions, particularly as regards non-discrimination on the grounds of gender, race or religion, respect for fundamental rights, accessibility, etc.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
Understand the basic laws about the working principles of fluid machines	B1 B4 B6	C45	D1 D3 D4 D5 D10
Acquire skills on the process of hydraulic installations sizing	B1 B2 B4	C45	D1 D2 D3 D10

Contents

Topic	
1.- Machines of fluid	1.1 Introduction. 1.2 Classification of fluid machines. 1.3 Main parts of a positive displacement machine. 1.4 Positive displacement principle for a machine. 1.5 Main parts of a turbo-machine. 1.6 Classification of turbo-machines. 1.7 Continuity equation. 1.8 Angular momentum conservation law. Euler's theorem. 1.9 Euler's equation. 1.10 Bernoulli's equation (relative movement) 1.11 Degree of reaction. 1.12 Losses in fluid machines: hydraulic, volumetric, mechanical. Efficiencies and power diagram. 1.13 Similarity in hydraulic turbo-machines. Specific speed.
2.- Hydraulic pumps. Classification and constituent elements. Pumping facilities.	2.1 Classification and constituent elements of hydraulic pumps. 2.2 One-dimensional theory of turbo-pumps: radial and axial flow. 2.3 Two-dimensional theory for turbo-pumps: radial and axial flow. 2.4 Basic design parameters of radial turbo-machines. 2.5 Basic design parameters of axial turbo-machines. 2.6 Characteristic curve of radial pumps. 2.7 Characteristic curve of axial and diagonal pumps. 2.8 Similarity in turbo-pumps. Particular cases. 2.9 Impeller trim on radial turbo-machines. 2.10 Pump-installation coupling. Selection of machines. Arrangement of pumps in series and in parallel. 2.11 Priming a pump. 2.12 Cavitation in centrifugal pumps 2.13 Introduction to the phenomenon of water hammer in pumping installations.
3.- Hydraulic turbines and hydroelectric power stations	3.1 Classification of hydraulic turbines. 3.2 Pelton Turbine. 3.3 Francis Turbine: Slow, normal and fast. 3.4 Axial turbines: Kaplan and propeller. Bulb groups. 3.5 Basic aspects on the regulation of hydraulic turbines. 3.6 Similarity in hydraulic turbines. Parameters of interest.
4.- Hydroelectric facilities: use of hydraulic energy.	4.1 Introduction 4.2 Classification and types of uses 4.3 Singular elements: dam, reliefs, water pipes and penstocks. 4.4 Accessory devices. 4.5 Water hammer in penstocks. 4.6 Surge tanks and other elements of protection.

Planning

	Class hours	Hours outside the classroom	Total hours

Lecturing	16	28	44
Practices through ICT	4	4	8
Laboratory practical	10	15	25
Problem solving	20	3	23
Autonomous problem solving	0	47.5	47.5
Essay questions exam	1	0	1
Problem and/or exercise solving	1.5	0	1.5

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
	Description
Lecturing	Oral presentations and dissertations in the classroom, developing the different topics of the course. It is strongly recommended that the student has previously read the material at home in order to contribute with questions or doubts during class-time.
Practices through ICT	Some basic method of solving problems associated with the coupling of pumps, application of the laws of similarity and calculation of installations and networks using generic calculation programs will be addressed: spreadsheet and/or mathematical software. The licenses will be GNU GPL, or a commercial one funded by the school/university.
Laboratory practical	Up to three laboratory practices will be carried out in order to clarify knowledge acquired in the classroom. The relevant guides will be provided for each practice in such a way that, after data collection, they can return to the teacher the results and conclusions of the experimental work, after a deep analysis of them.
Problem solving	Exercises are previously given to the students, bringing them a try to solve by themselves. Later, some of them will be solved in class by the students and/or the teacher
Autonomous problem solving	The students will solve the proposed problems. They can ask for support during the scheduled tutorship hours.

Personalized assistance	
Methodologies	Description
Autonomous problem solving	Personalized attention will be given to the students during class (throughout the possible questions that could arise) and during the specific timetable of the teacher for tutorship. Updated information of the tutorship timetables will be given to the students during first week of class. Tutorshiping will take place both in face-to-face or distance modes, by means of the e-learning applications offered by the University of Vigo or equivalent methods.

Assessment				
	Description	Qualification	Training and Learning Results	
Laboratory practical	Submission of a report/questionnaire and/or oral examination of at least two experimental/IT practices to be carried out throughout the course. Consult detailed methodology in the section "other comments on the evaluation".	10	B1 B2 B4 B6	D1 D2 D3 D4 D5
	EXPECTED RESULTS: Comprise the fundamental laws about the basics in fluid machines. Acquire skills on the process of hydraulic installations sizing.			
Problem solving	These are two continuous assessment tests that will be carried out throughout the course. They will consist of written exercises/problem solving tests. Each one will have a weight of 12.5% of the total grade. Consult detailed methodology in the section "other comments on the evaluation".	25	B1 B2 B4 B6	D1 D2 D3 D5 D10
	EXPECTED RESULTS: Comprise the fundamental laws about the basics in fluid machines. Acquire skills on the process of hydraulic installations sizing.			

Essay questions exam	It will consist of two written tests that may consist of: theoretical / practical questions that include resolution of exercises and problems and/or topic to be developed. Each test will represent 12.5% of the total grade. For more information, see the detailed methodology in the section "other comments on the evaluation"	25	B1 B2 B4 B6	D1 D2 D3 D5 D10
<p>EXPECTED RESULTS:</p> <p>Comprise the fundamental laws about the basics in fluid machines.</p> <p>Acquire skills on the process of hydraulic installations sizing.</p>				
Problem and/or exercise solving	This test will coincide with the official exam established in the center's calendar. It will consist of a written test for the resolution of exercises / problems. Consult the detailed methodology in the "other comments on the evaluation" section.	40	B1 B2 B4 B6	C45 D1 D2 D3 D4 D5 D10
All the EXPECTED RESULTS IN THE SUBJECT are worked with this methodology.				

Other comments on the Evaluation

The student will be able to freely choose the evaluation methodology (Global or Continuous) within the established deadline and procedure set by the school, and in any case in accordance with current regulations.

The problem of students choosing one evaluation methodology or another, according to the maximum weights established, is most dramatically manifested in the case of two students who take the final exam/retest and obtain exactly the same grade (for example, 6/10); one passes because he has chosen the global evaluation, while the other fails because of selecting the continuous evaluation and only obtained a 4.2 out of 10 in the average of the continuous evaluation tests.

To mitigate this contradiction in the regulations in the case of continuous assessment mode, two grades will be calculated for each student, and the higher of the two will be selected.

Continuous Evaluation Mode

In the calculation of the final grade, four evaluation blocks will be considered with the following weights:

- First partial test of continuous evaluation, weight: 25%. Test consisting of theoretical/practical questions, including problem-solving and/or a topic to develop. It may include multiple-choice questionnaires.
- Second partial test of continuous evaluation, weight: 25%. Test consisting of theoretical/practical questions, including problem-solving and/or a topic to develop. It may include multiple-choice questionnaires.
- Final test of continuous evaluation (retest), weight: 40%. Test consisting of theoretical/practical questions, including problem-solving and/or a topic to develop. It may include multiple-choice questionnaires.
- Practical work, weight: 10%. Submission of a report/questionnaire and/or oral examination of at least two experimental/IT practices to be carried out throughout the course.

In the spirit of the above paragraph, the final course grade will be assigned to all students using the following formula:

$$\text{Final Grade} = \max \{0.6 \text{ NC} + 0.4 \text{ NF}, \text{NF} + (1/20)\text{NC}(10 - \text{NF})\}$$

where NC is the weighted average of the two continuous evaluation tests and practical (in the range of 0 to 10) and NF is the grade of the final exam (retest) (also out of 10).

Global Evaluation Mode

A final exam will be held on the official date approved by the school, with a maximum score of 100%.

Second opportunity call

In the second opportunity call (extraordinary in July), the same methodology as in the first opportunity will apply, with a new final evaluation test for students who choose continuous evaluation and a new final exam for those following the global evaluation. In the continuous evaluation mode, therefore, the grades of the partial tests and practical work are retained.

Exam Timetable: Exam dates and rooms must be verified in the official webpage of the school:

Sources of information

Basic Bibliography

Round, George F, **Incompressible Flow Turbomachines. Design, Selection, Applications, and Theory**, 1ª ed., Elsevier - Gulf Professional Publishing, 2004

Agüera Soriano, José, **Mecánica de fluidos incompresibles y turbomáquinas hidráulicas**, 5ª ed., Editorial Ciencia 3, S.L., 2002

Mataix Plana, Claudio, **Mecánica de fluidos y máquinas hidráulicas**, 2ª ed., Ediciones del castillo, S.A., 1986

Hussain, Z. and Abdullah, Z. and Alimuddin, Z., **Basic Fluid Mechanics and Hydraulic Machines**, 1ª ed., CRC Press, 2009

Modi, P. N. and Seth, S. M., **Hydraulics and Fluid Mechanics Including Hydraulic Machines (In SI Units)**, 15ª ed., Standard Book House, 2004

Complementary Bibliography

Mataix Plana, Claudio, **Turbomáquinas hidráulicas**, 2ª ed., ICAI, 2009

Girdhar, P. and Moniz, O, **Practical Centrifugal Pumps. Design, Operation and Maintenance**, 1ª ed., Elsevier - Newnes, 2005

Hernandez Krahe, Jose Maria, **Mecánica de Fluidos y Máquinas Hidráulicas/Unidades Didácticas V y VI**, 1ª ed., UNED, 1995

Kothandaraman, C. P. and Rudramoorthy, R., **Fluid Mechanics and Machinery**, 2ª ed., New Age International (P) Ltd., Publishers, 2007

Vasandani, V. P., **Theory and Design of Hydraulic Machines Including Basic Fluid Mechanics**, 11ª ed., Khanna Publishers, 2010

Gulich, Johann F., **Centrifugal Pumps**, 3ª ed., Springer, 2014

Kumar, P., **Hydraulic Machines: Fundamentals of Hydraulic Power Systems**, 1ª ed, CRC Press, 2012

Bansal, R. K., **A Textbook of Fluid Mechanics and Hydraulic Machines (in SI units)**, 1ª ed., Laxmi Publications, 2005

Gupta, S. C., **Fluid Mechanics and Hydraulic Machines**, 1ª ed., Pearson Education Canada, 2006

Patra, K. C., **Engineering Fluid Mechanics and Hydraulic Machines**, 1ª ed., Alpha Science Intl Ltd, 2012

de Lamadrid Martínez, Abelardo, **Máquinas hidráulicas. Turbinas Pelton. Bombas centrífugas**, 1ª ed., Servicio de Publicaciones, ETSII - UPM, 1986

Recommendations

Subjects that it is recommended to have taken before

Circuits and electrical machines/V09G311V01201

Fluid mechanics/V09G311V01204

Other comments

It is recommended to have previously passed a Fluid Mechanics course.

Skills specifically worked on in this subject:

CE45. Know, understand and use the principles of hydraulic works and installations. Planning and management of hydraulic resources.